# Implementing Change Through Planning and Analysis

Vice Admiral **Patricia Tracey**
Deputy Assistant Secretary for Military Personnel (OSD)

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The Navy's individual training and education system is grounded in a proven process. It has a long history of providing highly qualified and motivated Sailors to the fleet. But like almost every other system today and, particularly, any training/education system, rapid change is affecting almost every component of the process. To prepare Sailors for the 21st century, the individual training system had to be reengineered. This was accomplished through quantifiable methods and prudent risk taking to enable us to continue to deliver a highly qualified technician and motivated Sailor to the fleet.

The demographics of incoming students from today's environment yield more diversity in factors ranging from cultural backgrounds, exposure to technology, gender, team working skills and a host of other societal factors. The rapid rate of technological advancement has greatly increased the sheer volume of "must know" technical knowledge essential to mission accomplishment. The increasing use of commercial off-the-shelf equipment has significantly reduced the time available to design and implement supporting training and education. The information age and Network Centric Warfare have brought a requirement for increasing skill in information management and more complex and quicker decision making. All of the above, coupled with the increasing variety and number of missions and the increased emphasis on joint and multinational warfare, also portend a need for an increase in leadership skills.

The driving factors listed above as well as the current fiscal environment led the Chief of Naval Education and Training (CNET) to reach the following conclusions.



**Vice Admiral Patricia Tracey**

Operational Tempo (OPTEMPO) will remain the same or increase, the rate of change will continue to accelerate and the Navy cannot afford — in terms of resources, time and fleet support — the current individual training system. The current system does not optimally support the accession reality that 45% of recruits enter the Navy in the months of June through September. Factors both within and outside the control of training currently result in executing more than the training and education command's share of individual account resources. The Navy's current individual training system, as currently configured, is not capable of effectively and efficiently preparing the Sailors we need for the 21st century.

The question confronting us is how do we restore productivity to the individual

training/education system while reducing the amount of resources needed to operate the system and maintain the number of high quality graduates the fleet needs. During the analysis on factors influencing the system, the CNET staff reviewed available data from numerous sources and focused their efforts on advances in training technology and methodology. As a result, the Navy is currently experiencing a measurable level of success with initiatives such as video-tele-training and computer-based training. New information from academia, industry and other government agencies support an assumption that a systematic approach to applying these new and evolving learning technologies and methods will have a major positive impact on the productivity and success of the individual training/education system.

To begin this systematic approach, CNET developed a course analysis model that established criteria for evaluating and categorizing courses based on their technology reengineering potential. For example, courses with student throughput of 100 students or less, that were 90% or more lecture in content and less than three days in length became prime candidates for video-teletraining delivery. In establishing criteria for electronic classrooms, courses with student throughput greater than 250, with a minimum of 60% lecture and a course length of 8 weeks or longer, provided the fastest and greatest return on investment. Academic attrition factors and setback rates were then applied to establish criteria for learning resource centers, focusing on courses with attrition greater than 6%, setbacks greater then 10% and throughput greater than 200.

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# Developing the Junior Analyst for 1998/99 — End of Third Quarter

**Dennis Baer**
MORS President

Three months have quickly passed since the last article. Since my "halftime" report, "your" Society has been busy preparing for the two special meetings before our big finale — the 67th MORSS at West Point 22-24 June 1999. We are happy to see the daily interaction between the Senior and Junior analyst going on within the Society and the Operations Research community in general. I would also like to welcome our newest Director, CAPT **Bob Eberth**, USNR. Although we have three quarters of the game behind us, the fourth quarter is a big push with another mini-symposium in March, the Education Colloquium in April and final preparation for the 67th MORSS in June.

Also keep in mind, that after this game ends at the 67th MORSS, we must start to prepare for the next game, which is from the 67th to the 68th MORSS. President Elect Dr. **Bob Sheldon** is presently guiding this effort. The Society is taking a strategic look at our Special Meeting topics for the next two years to ensure a logical flow and MORS is meeting the needs of the DoD analytical community. I will expound on these special meeting topics in my next article, after I have received concurrence from our six DoD Sponsors. You will also hear about these meetings during the plenary session at the 67th.

## Secretary

Dr. **Tom Allen**, Secretary (Institute for Defense Analyses), has been at the helm for the past year guiding both the Membership and Electronic Media Committees. The Membership Committee has been ably headed by Dr. **Dean Hartley** (Data Systems R&D Program). One of the many important functions of the membership committee is to nominate the Fellows of our Society. This year the Board of Direc-

tors elected three new Fellows of the Society during the December board meeting. We would like to sincerely congratulate Mr. **Brian McEnany**, PP, (SAIC); Dr. **Stuart Starr** (MITRE), and Dr. **Harry Thie** (RAND). These three "gentlemen" will be inducted during the opening plenary session at the 67th MORSS in June at West Point.

Hopefully, you've had an opportunity to visit our web site at www.mors.org. This web site has made great strides the past few years, due largely to the efforts of Ms. **Corrina Ross** of the MORS staff and our Electronic Media Chair Mr. **Glen Johnson** (US Arms Control and Disarmament Agency).

## Finance and Management

Many thanks to the entire membership, the management committee, and the MORS staff for a great year financially in 1998. See the VP(FM)'s article by Ms. **Sue Iwanski**, (Systems Planning and Analysis) in the June issue for details on the management committee composition and their accomplishments this year.

## 67th MORSS

You should have already received your registration packets in the mail. **Anne Patenaude** and her staff have done an outstanding job preparing and organizing this Symposium, but it is missing one main ingredient — your participation. Please remember to submit your application by the 16 April deadline for regular registration fees. After that applications will be accepted, but the registration fees will increase. If you haven't already made your hotel reservations, open the registration packet to page seven and make them NOW. Hotel space is limited and there are not many campgrounds nearby.

## New Sponsors

I had the pleasure of meeting and introducing MORS to our two newest Sponsors. They are RADM **Raymond Smith** of N81 within the OPNAV staff and MajGen **Kenneth Hess**, who is Director of Command

and Control within the Air Force headquarters staff. Welcome aboard!

## Use of the Theme – "Developing the Junior Analyst"

The Education Colloquium is one of the major events of the year on the professional affairs side of the house. This year's colloquium features the junior analyst. Please take time to read the VP(PA)'s article by CAPT **Lee Dick** in this edition. I continue to see great payoffs in the time invested in the development of our junior analysts.

## Hold Up Those Four Fingers

You will often see players holding up four fingers at the beginning of the fourth quarter of football games. This helps the players recognize this is the fourth and final quarter of the game. Regardless of all the sweat lost during the first three quarters, you must make that extra push into the last quarter to finish the game a "winner," regardless of how far ahead or behind you are. We are indeed entering the fourth quarter of the game with much to complete in terms of meeting preparation and execution. We cannot be successful without your hard work and participation. Just ensure one thing while you are in the ballgame — teach the "rookie" beside you how to play the game. Keep strokin.' ✪

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**Upcoming MORS Meetings**

**Education Colloquium**
22, 23 April 1999
ANSER Headquarters, Arlington, VA

**67th MORS Symposium**
22, 23, 24 June 1999
US Military Academy
West Point, NY

# Setting Goals on Our Educational Cornerstone



Dr. **Bruce Fowler**
MAS President

I just returned from the Army Simulation and Modeling for Acquisition, Requirements and Training (SMART) Conference in San Antonio. **Diane Scharein,** TRADOC HQ, had asked me to attend so I could support the Requirements Breakout Session she and COL **Mike Lavine**, Office of the Assistant Secretary of the Army for Research Development and Acquisition (SARDA), ran, and be my usual obnoxious self. Normally, I tend to pass up these management-stakeholder conferences for the technical ones, but that would have been a mistake. The information and interaction were great and I offer kudos to LTG **Paul Kern** and Dr. **Herb Fallin**. I came away with some technical challenges for the profession that I want to share: Physics Based Operations Research; and Systems of Systems that frequently collapse into Mega-Systems.

Before I go any further, I need to recognize Ensign (then Cadet) **Jeff Kuck** who received the MAS OR Student Award when he graduated from the US Coast Guard Academy in Operations Research. CAPT **Len Kelly**, Chair, Mathematics Department hosted the ceremony; **Jim Malley**, Textron Systems (a 20 year MASite) presented the award. Congratulations Jeff! We have great expectations of you. (For more details on all 1998 MAS Awards visit the MAS web page at www.informs.org/subdiv/Societies/MAS/index.htm

In his last message, my predecessor Dr. **Tom Gulledge**, George Mason University, mentioned that I would be succeeding him. This will definitely not be a replacement; Tom leaves some big shoes to fill and time will tell how well this simple county boy from North Alabama will do. We owe Tom a big debt for his leadership but he will still be around as Past President and INFORMS Vice President, Meetings to keep us in the roadway with his wise counsel. Dr. **J. P. Ballenger**, Raytheon, is our new Vice President and President-Elect, and Dr. **Philipp**



*MAS OR Student Award winner*
*Ensign Jeff Kuck*

**Djang**, TRAC White Sands Missile Range (WSMR), is our new Secretary-Treasurer. Dr. **Greg Parnell**, Virginia Commonwealth University, and Dr. **Ralph Toms**, SRI are our new Councilors-at-Large (CAL). Tom Gulledge also appointed Dr. **Pauline Cason**, SAIC, to serve out the remainder of Philipp's term as CAL as one of his last official acts.

Our geographic chapter, the Redstone Arsenal – Huntsville Military Operations Research Section (RAHMORS) also installed new officers. The Past President, Dr. **Jeff Cerny**, AMCOM, was elevated to the Executive Council and after his four year term will automatically become a Graybeard of the Section (GS), which is fitting since his beard is showing a lot of gray these days. **Ray Livingston**, TBE, moved on to become Past President, and was succeeded by **Hugh Griffis**, Signature Research, as President. **Sam McNulty**, SAIC, was installed as Vice President, Mrs. **Martha Knott**, was returned as Secretary, and Dr. **John Hall**, TASC was installed as Treasurer. RAHMORS has some good ini-

tiatives going and I will try to share them in later columns. One of Hugh's first acts was to present me the first RAHMORS Light Sabre, which I am sure is destined be highly coveted.

One of my first acts as President was to institute the *President's Award*. This award consisting of a medal and a certificate, is to be presented to anyone who, in the President's view, has significantly contributed to the advancement and wellbeing of the Society or the Profession. This is an "as required" rather than an annual award and is awarded at the discretion of the President. During our business meeting at the Seattle INFORMS Meeting, I presented President's Awards to **Ray Livingston**, TBE, for his service as Chief of Staff of our first independent national meeting, 1MAS, **Pat Murphy**, CAA, for service as Track Chair of the Seattle meeting, Dr. **Dean Hartley**, ORNL, for his service as President and Division Representative, Dr. **Steve Balut**, IDA, for his service as President and Editor of *Topics in OR*, and Dr. Tom Gulledge, GMU, for his service as President. Subsequently, I also presented a President's Award to COL **Tony Brinkley**, (Ret) GS, Vitronics (then TBE), for his service as General Chair of 1MAS. I solicit your nominations of deserving recipients of this award.

A good president is supposed to come into office with a set of goals and objectives, a program, if you will. One of my goals is to increase opportunity for professional development. We have a strong foundation in our technical track at the INFORMS national meeting, our annual national meeting and the Topics in Operations Research. A lot may be done however, to improve both individual and collective educational opportunities. The service schools and some of the universities provide a great deal, but not everyone can attend the Naval Postgraduate School or AFIT. I would like to build on this by expanding the number and scope of available reference and text materials, and classroom opportunities, by developing both model courses for export to universities and actual course-

# Junior Analysts — You Can Play a Part

CAPT **Lee Dick**
PMW 131

As we continue to expound on the 1999 MORS theme of "Developing the Junior Analyst," I've issued some challenges for you within each of the Professional Affairs committees. The care and feeding of young analysts is not solely the responsibility of our educational institutions, nor the Society as a whole. But rather it more importantly hinges on the day-to-day direct contact that each of us in supervisory or senior peer positions play in developing the techniques and the allegiance that will one day make them leaders in our field.

## Education and Professional Development Committee

The premier Junior Analyst event of the year is fast approaching next month. If you have not already made plans to send your junior analysts to the Education Colloquium on 22-23 April at ANSER HQ in Crystal City, please mark the dates on their calendars and try to get them interested in attending. I would like to challenge each supervisor to ensure that your office is represented by at least one junior analyst at the 99 Colloquium. I have passed the information along to the entire Director of Naval Training staff, with the goal of not only bringing our three Operations Analyst (OA) graduates to the event, but the majority of the staff as well. As the purveyors of training and education in the Navy, it will be a great opportunity to raise their level of analytical awareness, as well as providing some experts in training and education to dialogue with our analysts in attendance. A special thanks goes out to Major **Willie McFadden**, chairmen of the Education and Professional Development Committee for the effort he has put into the planning of this year's activity. Other committee members who deserve credit are Tutorials Coordinator **Dean Hartley**,

Junior Analyst Coordinator **Howard Whitley** and Panel Discussion/Special Presentations Coordinator Col **"Crash" Konwin**. The keynote speaker for this year's colloquium will be Mr. **Walt Hollis**, DUSA(OR), FS. Please check the MORS homepage http://www.mors.org frequently for updates.

## Prize Committee

So what do your junior analysts know about the MORS prize competitions for technical accomplishments? Are they aware of the $1000 Barchi Prize, the "Best of the Best" Prize, which is awarded to the best paper resulting from the best presentation in each working or composite group at the previous Symposium? Do they know about the $1000 Rist Prize which is awarded each year to the best paper received in response to an annual call for papers? This year, MORS received 24 papers to compete for the Barchi Prize and 18 papers to compete for the Rist Prize. The quantity and quality of this year's competition is exceptionally good. According to Prize Committee Chair Maj **Mark Gallagher**, we expect more prize competition papers will be published in *Military Operations Research* than any previous year. At the June Symposium, both the Barchi and Rist winners will present their work during a special session. In addition, the winners and those individuals receiving honorable mentions will also be asked to display their work during the Tuesday evening mixer.

## Heritage Committee

Have you introduced your junior analysts to a MORS classic this year? Why not plan to present the top analyst in your shop with a copy of the next MORS reprint when it becomes available later this year? **B. O. Koopman**'s book on Search and Screening was nominated as the next volume in the MORS Classics series. The Heritage Committee Chair Mr. **Ted Smyth** has obtained a copy of the book and provided it to the MORS staff which is in the process of contacting

the publisher to discuss copyrights and other legal issues.

The MORS Oral History project will be a great way to enable our junior analysts to learn about OR roots. Another oral history interview has been conducted, this time with Mr. **Clay Thomas**, FS, Chief Scientist, US Air Force Studies and Analysis Agency. The interview was conducted by Mr. **Gene Visco**, FS, with assistance from Dr. **Bob Sheldon**. The tape of the interview has been transcribed and is in the process of being edited. We plan to have an article on Mr. Thomas, with accompanying portions of the interview, appear in the spring edition of the *MOR* journal. In addition we hope to have an article in the *PHALANX* prior to the 67th MORSS and the award of the first Thomas Prize.

## Publications Committee

Do your junior analysts regularly read copies of the *PHALANX* and the *MOR* journal? Are they available to everyone in your shop? Have you told them about *PHALANX* Online and did they visit the web site to read the latest edition? The dissemination of information within the Society is key to maturing new analysts and in keeping our Society healthy and stimulated. As we continue to focus on the MOR analysts and the decision makers that use MOR analysis, the high quality and relevance of both *MOR* and *PHALANX* must be continued. We all recognize the importance of timely publication of special meeting reports. The Publications Committee, under the leadership of Mr. **Brian Engler**, and the MORS staff have been focused on clearing out the several-year Special meetings publication backlog. The Publications Committee, in coordination with the Special Meetings Committee, will continue to stress the timely production of Special Meetings publications. To that end, a joint sub-committee, chaired by Dr. **Stuart Starr**, FS, is examining special meeting publication procedures to see if they can be further streamlined. ✪

# System Stability: A Proxy for "Graceful Degradation"

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**James P. Ignizio, Ph.D.**

Within the military sector the notion of "graceful degradation" is universally accepted. Military systems (e.g., weapons, force mixes, communication links, air defense systems and even a "system" of strategies and tactics) should, it is agreed, *gracefully degrade* (e.g., under hostile conditions, or random failures, or variations in mission, or changes/modifications in personnel and equipment) — rather than collapse like a house of cards.

Unfortunately, there is no agreement as to how one defines *graceful degradation*, or how it is measured. Furthermore, and perhaps most unsettling, the attributes of *optimality* and *graceful degradation* may — if the hypothesis of this article holds — actually be in opposition. To illustrate this phenomenon, consider the simple "block world" problem depicted in Figure 1.

The stack of blocks on the left side of Figure 1 is unequivocally optimal *in the sense of being the taller* of the two stacks. However, while the stack on the right side of the figure is shorter, less impressive in appearance, and "sub-optimal;" it is also clearly far more stable. Given the choice between attempting to stand on either of the two stacks, most people would select the suboptimal stack. Clearly, something more than the height of the stack is important — something difficult to put into words or formulas.

In this article I explore the very real possibility that "optimal" solutions may be invariably unstable — wherein stability is defined as: *"the measure of both the speed and ease by which a given solution 'de-evolves' (degrades) to some minimally acceptable level."* In the case of the "block world" illustration given earlier, it should be apparent that the "optimal" stack is likely to collapse easier and faster than the shorter stack.

In addition, what would appear (based on results thus far) to be a practical and effective approach for the assessment of the stability of any given solution is presented. Its performance on a number of real world problems is described. I then contrast the inherent stability of solutions as produced by traditional optimization with those developed by evolutionary means (e.g., genetic algorithms, evolutionary computation).

While the results of my investigation have thus far upheld my *hypothesis* (i.e., that *unstable solutions de-evolve faster and easier than stable ones*), it should be made clear that these results have been limited to the (intensive) investigation of but nine problems (albeit real problems and real data). Since there would appear to be no way to investigate the phenomenon of stability other than empirically, it is hoped that this article motivates others to evaluate the process on their own set of (real world) problems.

Conventional wisdom holds that one should always strive for solutions that are optimal, or at least "near optimal." The idea of *intentionally* developing *non-optimal* solutions is, in itself, an anathema to the operations research profession — and particularly to the academic community. However, as a practicing OR analyst for more than 30 years, I have noted that a surprising number of "optimal solutions" to real world problems have led to unexpected and troubling consequences. Specifically, while such solutions may be optimal on paper, they prove to be problematic when actually implemented.

Just two of the many indications of instability of optimal solutions I have personally encountered are listed below:

**SAM-D**: SAM-D was the original designation for what is now known as the Patriot air defense system. In the late nineteen-sixties I was tasked with the development of a scheme for the deployment of the elements of such a system. In other words, to produce a method to locate the sites for the missile launchers and radars so as to minimize "leakage" (i.e., protect a region of airspace from attack by enemy aircraft). It was discovered that a branch-and-bound approach, which guaranteed optimal or near optimal solutions, also resulted in deployments that were extremely unstable. For example, if some combination of system elements (e.g., positions, weather, target signature) were changed — even slightly, air defense performance would often suffer a dramatic reduction. Yet, when deployed by means of a heuristic method, the results were quite stable — at the cost of but a very slight reduction in the "optimality" of the solution.
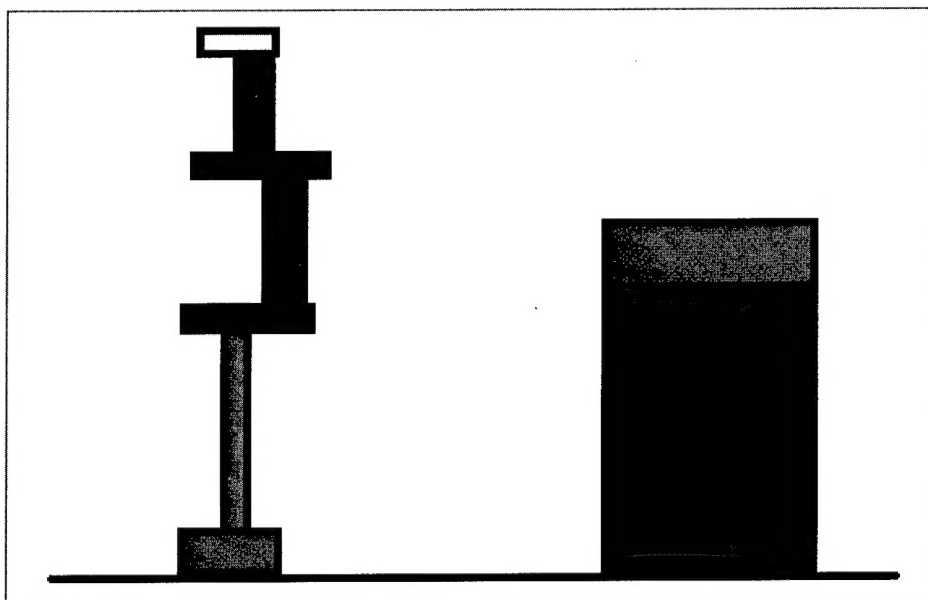


**Figure 1: "Optimal" and "Suboptimal" Stacks**

**Torpedo Acoustic Arrays**: Acoustic arrays for torpedoes (or electromagnetic arrays for radars) consist of a number of transducers, acting as an ensemble. These transducers are to be located in such a manner, and delivered power of such amplitude and phase, as to produce a beam pattern of a specified shape. In essence, the array design problem is one of combinatorial optimization, and may be formulated and solved by conventional methods for an optimal solution. However, once these "optimal" acoustic arrays are constructed and tested (typically in a water chamber, under a variety of conditions), the actual performance may be, in a word, *awful*. Just a few seemingly insignificant changes in a combination of parameters (e.g., a slight decrease in temperature coupled with a small increase in pressure) can, and often does, result in sudden and dramatic degradation of the beam pattern. As such, a design that is optimal on paper may well be impractical for application.

While numerous other instances could be cited, all have a similar property. That is, optimal solutions, even when accompanied by intensive (but conventional) sensitivity analysis, are often found to be highly unstable. Yet solutions that are heuristically derived, and clearly sub-optimal, can be as "solid as a rock."

Based upon these experiences, coupled with a long-time interest in heuristic methods (particularly those that mimic evolution, such as genetic algorithms), I sought to test the following hypothesis:

**Inherently unstable solutions will de-evolve *faster* and *easier* than stable solutions.**

To determine the validity of this hypothesis, a "reverse" genetic algorithm was developed. That is, instead of starting from a poor (or randomly selected) solution and seeking to evolve to more fit solutions, my algorithm begins with any given solution (e.g., the solution to be tested for stability) and *de-evolves* to less fit solutions. It was (as implied in the hypothesis) my conjecture that an unstable solution would de-evolve (e.g., collapse) in fewer generations than a stable one.

For those unfamiliar with genetic algorithms, a list of resources is provided at the end of this article.

In brief, a genetic algorithm proceeds by first coding a trial solution into a "chromosome" (e.g., a pattern of zeros and ones that serve to represent the values of the

decision variables). Next, a population of solutions (chromosomes) is generated (typically randomly). From there, a parallel and probabilistic search procedure ensues. Solutions are evaluated for their "fitness." Those that are most fit are given a higher likelihood of being placed into a "mating pool." The mating pool is generated, stochastically, and solutions "exchange portions of their chromosomes" with their mates so as to produce new solutions (e.g., an exchange of a segment of zeros and ones in one chromosome, or coding, with those in another). Mutation (e.g., the "flipping" of a zero to a one, or vice-versa) then takes place (albeit with a very low probability) and the resulting set of solutions represent the "next generation." The process repeats until a given termination criterion is reached.

Since my intent is to find out how easy and fast a given solution *de-evolves* (rather than *evolves*), my genetic algorithm starts with the solution (chromosome) to be tested and works backwards. The pseudo-code for the de-evolution algorithm is provided below.

```
procedure De-Evolve:
begin
t=0
select chromosome, C(t)
perturb C(t) [to generate initial
    population, P(t)]
fitness P(t)
until (done)
        t = t + 1
        select P(t) from P(t-1)
        crossover P(t)
        mutate P(t)
        fitness P(t)
end
```

It is probably easiest to explain the process, and its interpretation, by example. Thus, first consider the results shown in Figure 2. In this figure, two solutions to the design of the "backbone" network for a telecommunications system are depicted. The diagnol symbol, to the far left of the figure, depicts the optimal solution to the problem (producing a normalized value of 100 for the measure of messages per unit time). The box symbol on the far left represents a solution derived via a genetic algorithm. Its value is 94 units, some 6 percent less than that of the optimal solution. Let

us assume that the *minimally acceptable level* of system performance is 60 units. Using the de-evolution algorithm, we then determine just how many generations are required for both solutions to degrade to the level of 60 message units.

Examining Figure 2, we see that the "sub-optimal" solution takes roughly *twice* as long (more than 20 generations) to degrade to the minimally acceptable level than does the optimal solution (which de-evolves to the minimally acceptable level in just 10 generations). In other words, the sub-optimal solution is apparently more stable than the optimal solution.

Of course, the result shown in Figure 2 might just be a fluke. After all, we are dealing with a stochastic search process. Consequently, the de-evolution algorithm is repeated numerous times (using different random number seeds) and the results presented in a histogram like that shown in Figure 3.

In Figure 3 it is apparent that the optimal solution (i.e., the de-evolutions shown to the left of the vertical dashed line) does in general de-evolve faster and easier than the suboptimal solution (those to the right of the dashed line, as originally derived by means of a genetic algorithm). Results of many more de-evolutions, as well as the investigation of some eight other real world problems confirmed this observation. One of these eight problems was that of the siting of the elements of the Patriot Air Defense System.

Using data from the original SAM-D air defense study, I developed a number of different siting schemes (e.g., location coordinates for the radars and missile launchers) for the air defense system. One of the solutions was optimal, having been derived via a tedious and time consuming implicit enumeration method. Another solution was derived by means of a genetic algorithm. All other solutions (eight more in total) were developed by various perturbations of these two results. The problem parameters were that of the precise coordinates where each element of the air defense systems was located, the estimates of terrain topology and weather parameters. The fitness of the solution was based upon the amount of airspace covered by the air defense system. The results are shown in Table 1.

*(See **STABILITY**, p. 8)*

Examining Table 1, we note that the global optimal solution is air defense system A; the one developed via implicit enumeration. Solution F is the solution developed by means of a genetic algorithm. Not only is solution F not optimal, it is actually dominated by solution C. That is, C is both cheaper and has a higher measure of effectiveness than F. If we were to stop our analysis at this point, solution F wouldn't look very attractive at all.

However, after applying the de-evolution algorithm to all ten solutions (and after repeating the process numerous times, using different random number schemes), it was found that solution F was, far and away, the most stable solution of all those tested. Solution A, the "optimal" scheme, fell apart with only slight changes in various combinations of model parameters.

Thus we are left with the following choice. We may either pick the global "optimal" solution (or any solution with a higher effectiveness to cost ratio than solution F), and suffer the consequences of moderate to extreme instability, or select the rock-steady solution F — at a slight reduction in the efficiency to cost ratio. When one considers the fact that the minor difference in effectiveness to cost could well be a result of errors in data (and all real world problems have such errors), solution F starts looking *very* attractive.

As mentioned earlier, results on nine different, real world problems, have all substantiated my original hypothesis. Does this mean that optimal solutions are always unstable? Or that solutions derived by genetic algorithms are always more stable than optimal solutions?

The short answer is no. Just nine experiments obviously cannot prove or disprove the hypothesis. However, these nine, highly consistent results *should* make the OR community take pause. Hopefully this article will encourage others to investigate this matter also. The more empirical evidence in support of this article's hypothesis, the more wary any OR practitioner should be of unquestionably accepting the doctrine of "optimality."
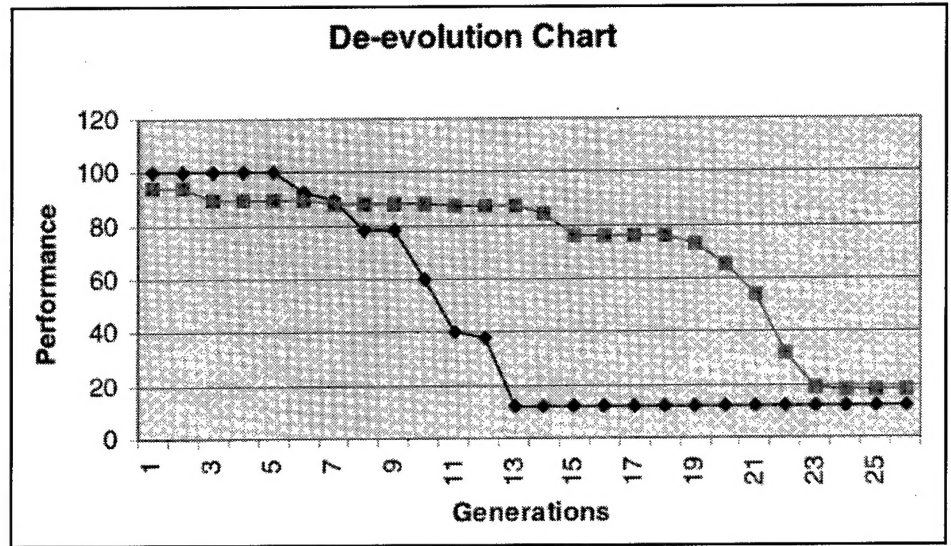
**Figure 2: The de-evolution of two different solutions to a network design problem**
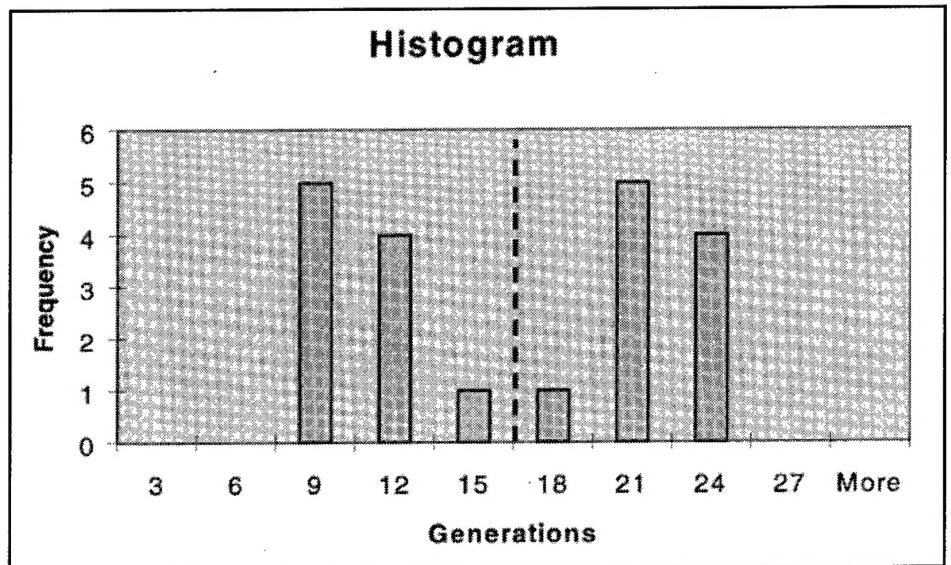


**Figure 3: Histogram of De-evolutions**

| Candidate System | Cost | Effectiveness | Effectiveness to cost ratio |
|---|---|---|---|
| A | 50 | 80 | 1.6 |
| B | 48 | 76.32 | 1.59 |
| C | 52 | 84.42 | 1.585 |
| D | 54 | 84.78 | 1.57 |
| E | 49 | 76.44 | 1.56 |
| F | 53 | 81.62 | 1.54 |
| G | 56 | 84 | 1.5 |
| H | 57 | 79.8 | 1.4 |
| I | 56 | 67.2 | 1.2 |
| J | 59 | 64.9 | 1.1 |

**Table 1**: Candidate Air Defense Systems

# Revolutions in Military Affairs, New Measures of Effectiveness and Good Old Fundamental Objectives

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Lieutenant Colonel **Dan Maxwell**

## Introduction

The 21st century promises the availability of advanced defense technologies that will revolutionize Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance ($C^4ISR$) activities. There are systems being designed and built to support military decision making in deliberate command and control activities, and to automate the "sensor-to-shooter" linkages; making precision fires more lethal. Joint Vision 2010 prescribes an "operational template" that capitalizes on these emerging technologies.[1] Many military experts assert that these technologies and the doctrine they support constitute a Revolution in Military Affairs (RMA). The belief is that this revolution will provide the United States' military the ability to dominate any projected opponent on the battlefield of the future.

The military operations research community is a key part of the intellectual effort supporting the asserted RMA. Computer-based simulation results are used as key evidence of both individual system effectiveness and improvements in "force effectiveness." The operational testing community assures military leadership that the systems the Department of Defense (DoD) plans on acquiring meet the specified operational "requirements." Analysts support warfighting experiments and collect data that "prove on the ground" the success of the RMA. We, in the military operations research community, are the purveyors of quantifiable evidence that demonstrates the increasing effectiveness of the US military.

There is also a significant intellectual effort that is seeking to identify new Measures of Effectiveness (MOE). That effort seems to assume that the hypothesis has been accepted; that the RMA is a proven replacement for existing capabilities and doctrine. There also seems to be an assumption that the underlying objectives of warfare are changing. Yet, there are historical examples that indicate we should be very cautious in drawing such sweeping conclusions about military effectiveness or model based analysis.

One example of misinformed analysis occurred between World War I and World War II in France. The French military invested heavily in the creation of the Maginot Line. These significant investments were complemented by a carefully crafted and rigorously analyzed doctrine that emphasized coordinated, superior fires. However, the German's successful campaign around the line is unequivocal evidence that this strategy was not only not revolutionary, but a failure.[2] There is also relatively recent evidence outside military history indicating that analytically supported "certainty" can have unexpected and potentially devastating consequences. For example:

- On 28 January 1986, the space shuttle Challenger exploded over the Atlantic Ocean almost immediately after launch. A retrospective analysis of the decision process leading up to the launch indicated that the analysis supporting NASA leadership was flawed. The information presented to decision makers regarding a potential "O" ring failure did not highlight the impact of cold temperature on the part's reliability. Had temperature been highlighted in the analysis, the likelihood of "O" ring failure would have been identified as being very high.[3]

- In 1979 the Three Mile Island nuclear reactor released hazardous radiation into the atmosphere. The risk analysis that was provided to the Nuclear Regulatory Commission to support licensing decisions demonstrated the facility's safety.[4]

Joint Vision 2010 is similar to the French experience in that there has been a tremendous resource investment and it is supported by extensive analysis. The non-military examples are similar to the DoD's current decision support efforts in that they are largely based on computer-based simulation and mathematical modeling. The conclusion that can be drawn from all of these examples is that a nonzero probability exists (i.e. it is possible) that JV 2010's envisioned capabilities could fail to produce the intended results. Moreover, no amount of analysis or investment can guarantee success. Properly framed and conducted analysis can, however, minimize the likelihood of a catastrophic failure, and improve the potential for good outcomes in military operations.

This article presents a foundation for ensuring that analysis (operations research) can help focus the analytic community. There are three components:

1) Answer the right question. Models and analysis (and by implication MOE) must be relevant and anchored to the objectives that are appropriate for the decision space under consideration. Most models quantify these objectives in some manner. We will refer to them as "fundamental objectives."[5] The set of fundamental objectives describes a decision maker's essential reasons for being interested in the decision at hand.

2) Make significant cause and effect relationships transparent. Modeling and analysis in support of decision making are most useful when insight into a complex decision situation is achieved. This insight requires that the decision (option space) be clear, and that there be a clear causal connection between decisions and the relevant fundamental objectives. In complex models it is often necessary to create intermediate objectives, which we will refer to as "means objectives,"[6] to illuminate causal relationships. Means objectives derive their importance from their connection to other, more fundamental, objectives.

3) Acknowledge and address uncertainty. Uncertainties exist with respect to future scenarios, future weapon systems effectiveness and threat behavior. These

uncertainties must be explored to evaluate the robustness of potential choices in a decision situation.

These three concepts apply to all types of analysis. In fact, they are embedded somewhere in virtually every operations research textbook. This article focuses on issues and examples that are most relevant to campaign level planning and DoD level resource allocation decisions. Each of the three concepts is addressed in the following sections and some conclusions are offered in the final section.

## Fundamental Objectives

The "overarching" measures of effectiveness that are applied to support US military and political leaders must possess some essential properties if they are to foster better decisions. First, they must clearly connect decision makers' concerns to the analytical frame of reference. Figure 1 identifies two differing views of the defense decision environment. The top half is the view of a policymaker or military leader. Policymakers think in terms of strategic objectives. Military leaders tend to think in terms of military success in conflict. These broad goals tend to be difficult to describe and virtually impossible to quantify in a "raw" state.

The bottom half of Figure 1 displays the perspective of an analyst. Analysts must decompose the amorphous goals into sets of measurable objectives that capture the essence of the decision situation, usually implicitly connected to a set of alternatives that are of interest to decision makers. There are a number of paradigms used in analytic practice today to describe the essential elements of an analyst's activities. Keeney introduces a set of concepts he calls "Value Focused Thinking."[5] It is the vocabulary that we use in this discussion. He uses the term "fundamental objectives" to describe a decision maker's essential reasons for being interested in a decision situation. Fundamental objectives are quantifiable by definition, and are normally organized hierarchically. Each level of the hierarchy is a complete nonoverlapping description of objective above it, and the uppermost fundamental objective is referred to as the "overall fundamental objective." Measurements associated with the set of fundamental objectives can be
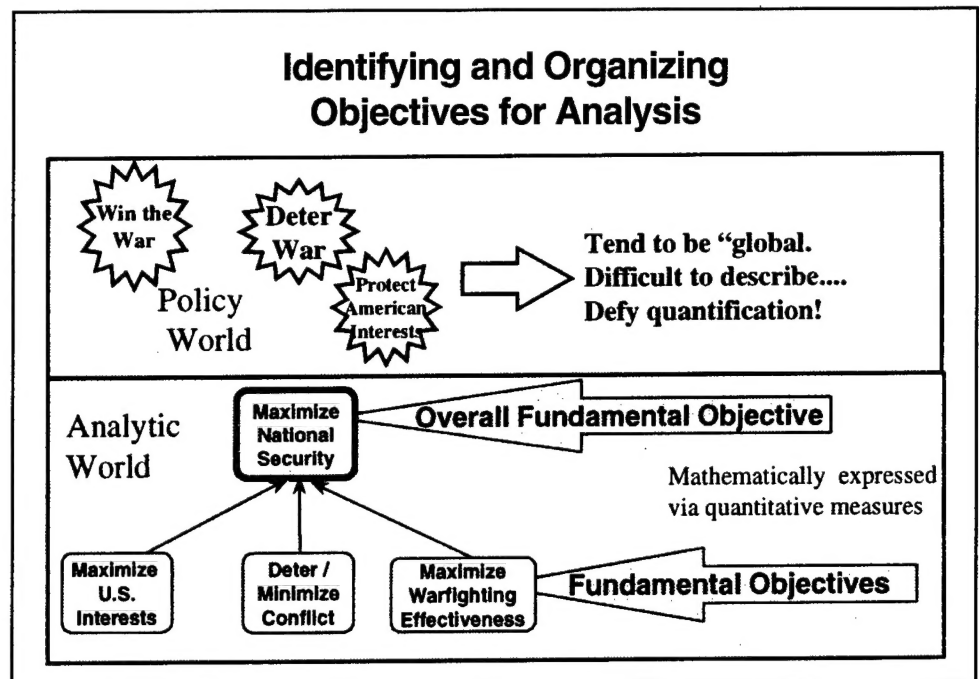


Figure 1: Interaction between policy and analysis.

combined via utility functions to express an overall satisfaction with a course of action. These utility scores can then be used to support comparative analysis.

In the context of national defense, America's strategic objectives are very stable. A flag officer or senior civilian leader could look to joint military doctrine and extract something like the following to articulate his or her policy-oriented understanding of the objectives: "National military strategy is to promote peace, deter aggression, and, failing that, fight and win."[7] This broad strategic statement might be refined into the following set of objectives:

- *Accomplish the assigned military mission.* This is the military's ability to restore or create a situation that is in the United States' interest. This must be evaluated (measured) in the context of a scenario, or some set of scenarios.

- *Minimize casualties.* Our culture values human life. Therefore, the cost of combat in human life should be minimized, for US military personnel, as well as enemy personnel and noncombatants.

- *Minimize conflict duration.* Armed conflict diverts the Nation's attention from other issues and consumes finite resources that could be invested in other areas.

- *Prevent repetitive aggression.* If a nation has demonstrated itself to be an aggres-

sor nation, we wish to preclude future difficulties with that nation by destroying its capacity to wage war.

- *Maximize force deployability.* The location of the "next" conflict is unknown and America's interests are global. Because of this it is in U.S. interests to maximize its ability to project combat power to other regions of the world in a minimal amount of time.

Figure 2 illustrates how these objectives might be organized and quantified into a set of fundamental objectives. These MOE are examples of the type that should be applied to help provide decision makers insight into many top-level decision situations. Judgments involving trades among these types of objectives are necessarily and appropriately subjective, and reflect the values (preferences based on experience) of senior military leaders. These objectives identify explicitly the point at which the analytical world intersects the decision makers' world. This intersection should be understandable for decision makers and span the multiple objectives that are affected by the decision and relevant uncertainties. The MOE are not new; they are a stable, enduring set of measures that link the analytic evaluation of policy and campaign level decisions to strategic objectives.

# Joint Simulation System Overview

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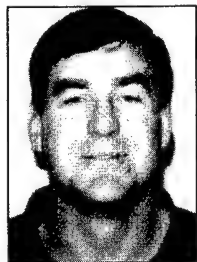
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## Abstract

The use of Modeling and Simulation (M&S) within the Department of Defense (DoD) has undergone a major change over the last several years. Unfortunately, the vast majority of the tools have not kept up with these changes. Current simulation systems do not provide the Joint Warfighter the capability to conduct joint and service training across the full range of military operations in a cost-effective manner. To address this critical shortage, DoD has undertaken the development of the Joint Simulation System (JSIMS). The JSIMS Program was created to address the shortcomings of existing systems, implement a collaborative development strategy for Joint and Service-specific capabilities, reduce the resource overhead required to conduct training exercises, and incorporate the common compliance paradigm for applicable standards and guidelines. This article covers the rationale for JSIMS and approach involved in bring this ambitious program to fruition.

## Warfare Is Evolving

Military operations in the twentieth century have gone through three phases of evolution. The first of these started with World War II, the Attrition Warfare era. Massed armies fighting discrete battles where the side left standing was declared the victor characterized this phase. In the late 1970's and early 1980's a new doctrine of Maneuver Warfare came into existence. Partially based on the lessons learned in Viet Nam, the determining factor was the ability to mass the forces at the critical time and place to defeat the opponent. While

this phase is still with us, we are entering a period where the military has a full spectrum of missions. While the United States military has always been used in non-traditional roles, it is now used in a much broader range. New missions, such as peace keeping, humanitarian assistance, and disaster relief, are stretching the envelope of the training of the armed services.

While the missions and the methods of the military have changed drastically, the simulations to support them have fundamentally remained the same. For the most part, they are large, monolithic, cumbersome, based on simplistic attrition algorithms, and biased to a particular service. As we progress in the highly dynamic world of the twenty-first century joint operations, the simulations used by the military must be able to reflect the new and evolving missions and tasks. To accomplish this, the Department of Defense is undertaking the development of a suite of new models. One of which, JSIMS, is the focus of this article.

## Distributed Users And Developers

While the recent draw downs and base closings have reduced the number of locations where the military is based, they still tend to be based by branch of service. This complicates and reduces the services' ability to train together. To do so, they have had to travel to central locations capable of hosting the exercise. Very often this has been the driving cost of an exercise. Likewise, due to teaming, skill mix, and political and economic considerations, the JSIMS Enterprise developers are no longer co-located. Developers located in Massachusetts, Florida, Virginia, California, Alabama, and the DC area routinely get together via video and tele-conferences to go over development artifacts that have been distributed electronically. While this ability to establish a virtual presence has greatly reduced the need for travel, much work still needs to be done to refine and understand the new paradigm.

## Warfighter Vision

The Warfighter vision is that JSIMS is a simulation system that supports the twenty-

first century warfighter's preparation for real-world contingencies. The system provides garrison and deployed exercise capability to meet current and emerging training and operational requirements in a timely and efficient manner. By interfacing to the warfighter's real go-to-war systems, the view into the simulation world mirrors that of the real world.

JSIMS will support Unified Combat Commands, Services and Joint Task Force training in all phases of military operations. It will also support specific Universal Joint Task List (UJTL) and service task lists requirements for strategic-theater, operational and tactical tasks.

## Consolidated Use Cases

As part of its definitional phase, seven prototypical use cases were developed. Each one of these represents a notional space in terms of fidelity and level of representation in which a class of user will use a JSIMS composition. The first two use cases, CINC/JTF/Component/Agency Training and Service/Agency Training, cover the same space as the current Joint Training Confederation (JTC). Together, these represent the Initial Operational Capability (IOC) functionality of JSIMS.

As JSIMS evolves to Full Operational Capability, the remaining five use cases, Planning Analysis, Crew/Team Rehearsal, Other Military Education, Senior Officer Education, and Doctrine Development will be met. At this time, JSIMS will have effectively covered almost the entire spectrum of the model space.

JSIMS will not be used in isolation. Rather, it is being designed to provide an overall context to the synthetic battlespace. It does this by interacting with other systems via well-defined interfaces. Per current DoD policy, the primary means of interacting with these systems will be via the High Level Architecture (HLA) data interchange mechanisms.

## Technical Vision

The Technical vision is that JSIMS is a single, distributed, seamlessly integrated simulation environment. It includes a core

## OVERVIEW

infrastructure and mission space objects, both maintained in a common repository. A common simulation engine includes system software to run on commercially available, open architecture hardware and networks. These can be composed to create a simulation capability to support joint or service training, rehearsal, or education objectives.

### Development Plan

The JSIMS developmental schedule is broken down into three major phases. The first phase is the program definition, which came to an end in the April, 1998 timeframe. During this timeframe, the contracts for the seven development efforts (shown in Table 1) were awarded[a], the JSIMS Enterprise was stood up, the Acquisition Program Baseline (APB) was signed, and Build 0 was completed. The signing of the APB represented a major advancement in the way programs are conducted. For the first time that anybody could remember, twenty-nine signatories, from the Program Managers to the service Acquisition Executives and Operations Deputies, all signed up to a common approach, set of requirements, and schedule. A by-product of the APB was the IOC requirements walkthrough. This allowed all of the developers to sit down with the requirements providers to gain a better understanding of the functionally needed to meet the user's needs. The importance of Build 0 was that, while a process build, it showed that the Enterprise could use the JSIMS Object Oriented Process (JOOP) to build executing software.

The next two components are both databases, but they serve different purposes. The Common Data Infrastructure (CDI) deals with the runtime data generated in an exercise. These data are used to restart the system and to evaluate the exercise. The Common Database is used to store the static data that are needed to help compose the simulation for the exercise and generate the scenario. The exercise generation and evaluation tools are parts of the next component, the Life Cycle Applications. The JSIMS LCA suite is an integrated set of tools to aid the users in the construction, execution, and analysis of an exercise. These are needed to help hide the complexity and details of the implementation of the

| Program | Development Domain |
|---|---|
| Joint Simulation System (JSIMS) Joint Program Office (JPO) | Joint Domain and Core Infrastructure |
| National Air and Space [Warfare] Model (NASM) | Air and Space Domain |
| JSIMS Maritime | Maritime Domain |
| Warfighter Simulation 2000 (WARSIM) | Land Domain |
| WARSIM Intelligence Module (WIM) | Tactical Intelligence |
| National Simulation (NATSIM) | Overhead and National Intelligence |
| Joint Signal Simulation (JSIGSIM) | Signal Intelligence |

**Table 1. The seven programs making up the JSIMS Enterprise**
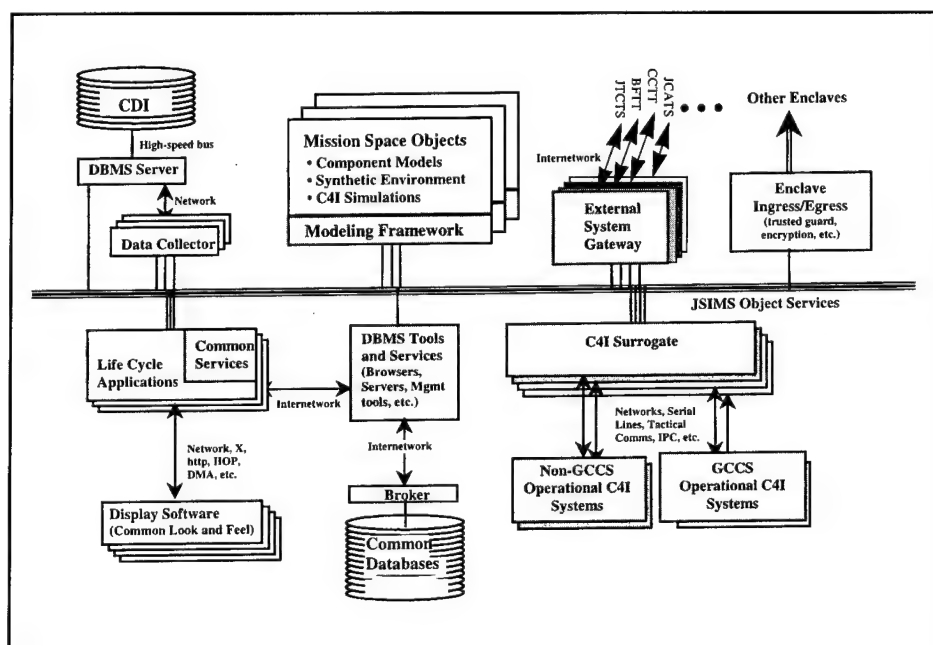


**Figure 1. The JSIMS Components**

users. The final component is the Enclave Ingress / Egress module or Security Gateway. The gateway acts as a trusted guard allowing informationto flow between JSIMS enclaves operating at different security classifications or compartments.

### System Development Process

Traditional software development process has used the big bang waterfall development process. Each step logically follows the other with the products coming down the waterfall. At the end of the water the system is delivered to the user. Experience has shown that this is not an effective way of building systems that are not fully understood at the outset or have the requirements change during development. These

types of systems, which include virtually all simulation systems, lend themselves to an iterative developmental approach. Each iteration is divided into roughly two phases. The first of these is the specification of a conceptual model based upon the current and best understood set of requirements. This model represents a formalism of the real world. Since the entire world will not be modeled, the system requirements are used to help filter and guide what is included.

Once the conceptual model is built, the requirements are again used to determine what functionality should be implemented in software vice met by manual or external processes. The software system is then,

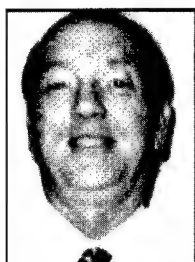# Authoritative Data Sources: How Do I Efficiently Find the Knowledge I Require?

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Have you ever had the dilemma of having to find a credible source of knowledge to support a model development or to populate a model database for a specific application? Those of you who have know the time expended in these type efforts is substantial. The Defense Modeling and Simulation Office sponsored data source cataloging effort has provided the Department of Defense (DoD) Modeling and Simulation (M&S) Community with a knowledge acquisition (KA) resource that expedites these efforts across the spectrum of M&S use.

The credibility of models and simulations is directly correlated to their representation of real tasks, systems and environments. Locating and acquiring the best available knowledge (data/information) is a key step in building that credibility. To address this need, DMSO, in accordance with direction within DoD Directive 5000.59-P (DoD Modeling and Simulation (M&S) Master Plan) to strengthen the use of M&S in the three functional areas; training, analysis and acquisition, established the Authoritative Data Source (ADS) Working Group (WG) in February 1994. The ADSWG consists of Service and Component modeling and simulation office representatives and M&S Executive Agent (M&S EA) representatives.

The ADS project is intended to improve data:

- Credibility (by designating authoritative data);
- Composability (by describing standard data); and,
- Cost (by rapid on-line identification and selected access).

The ADS Working Group has developed three key products:

- The ADS designation process, (Component sources are labeled with levels of authority);
- The ADS taxonomy of data source categories (taxonomy with definitions facilitate searches); and,
- The ADS library (list of sources with metadata descriptions).

There are four steps to the process that provides designated data sources to the M&S community.

1. **Identify the sources**. Senior representatives at the Service and Component modeling and simulation offices were requested to provide prioritized listings of their sources. The search was expanded by (1) obtaining inputs from major M&S users, (2) asking identified points of contact in key M&S organizations to identify other sources and (3) search of US Government and Military web sites.

2. **Gather a standard set of information**. The standard set of metadata being gathered was developed and approved by the ADSWG. The focus is on providing the information required during the knowledge acquisition phase of typical model development or employment. The content of the ADS metadata has been cross-walked with International Standards Organization standards, the Federal Geographic Data Committee standards for metadata and the Defense Data Dictionary System (DDDS). The standard set of metadata being included in the Library has recently been expanded to include detailed data quality information identified as required by the DoD VV&A working group's Data Quality Tiger Team metadata template.

3. **Designate each source with a level of Authority**. Designation provides M&S users with key information necessary to determine the appropriateness of the data for the need. Designations are assigned by the appropriate Service or Component responsible for the creation of the information.

Three levels of authority have been assigned in the past. Those levels were; Authoritative, Approved and Other. The designation naming convention and associated definitions are being modified. As of the writing of this article the new names and definitions have been formally approved by the Army, Air Force and Air & Space Executive Agent.

The new definitions are:

*Category I* — A recognized Service or National data production center with applicable mission statement, industry provider, or source/product that has established and documented production quality control procedures and quality controls the data produced. These organizations or sources/products have a reliable performance history. They have well-defined data metrics and significant metadata information, sufficient to satisfy all priority one Data Quality Template requirements (ADS mandatory metadata fields), available according to a recognized metadata standard.

*Category II* — A data producer or source/product designated by a Compo-

nent. Includes data providers and sources/products that, while not of the Category I stature, have become de facto providers of data or have unique, one-of-a-kind data sets and employ quality control procedures. This category includes providers of individual data sets that have been accepted or designated as research grade data sets. The category may also include industry providers who establish Component-approved M&S support systems. Their data may or may not have well defined data metrics and their metadata only partially satisfy the Data Quality Template priority one requirements (ADS mandatory metadata fields).

*Category III* — A producer, source, or product that is not Category I or Category II but is available for use as deemed appropriate by the user.

*T suffix* - Indicates source had been previously designated at the comparable level in accordance with the previous designation categories and definitions. However, the metadata set requires completion of applicable new data quality elements of information and subsequent review by the designating authority to ensure the level is still appropriate. It is envisioned that this will occur with the routine update/ review schedule of each source.

The old definitions were:

*Authoritative Data Source:* A source or product, which has undergone producer data VV&C activities.

*Approved Data Source:* A source or product that has been generated for a specific purpose and has been reviewed by the proponent and user and they agree to its validity and appropriateness for that use.

*Other Data Source:* A source or product that has not been designated Authoritative or Approved but is available for use as appropriate.

4. **Make the information readily available to the M&S community**. The value of the ADS metadata and designation lies in its use to reduce knowledge acquisition time. The metadata and associated designations that have been
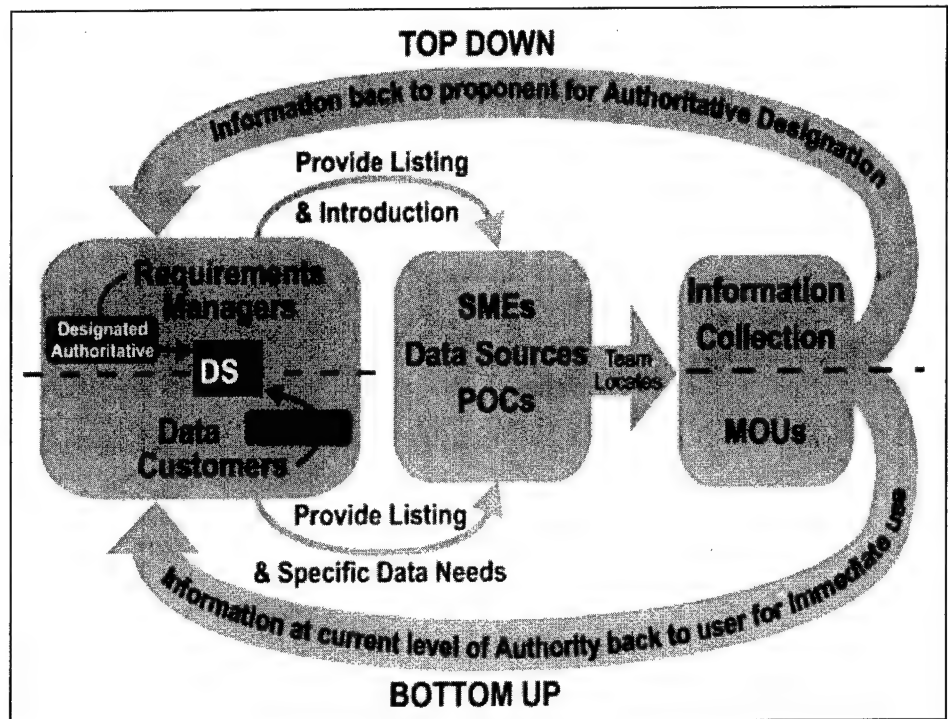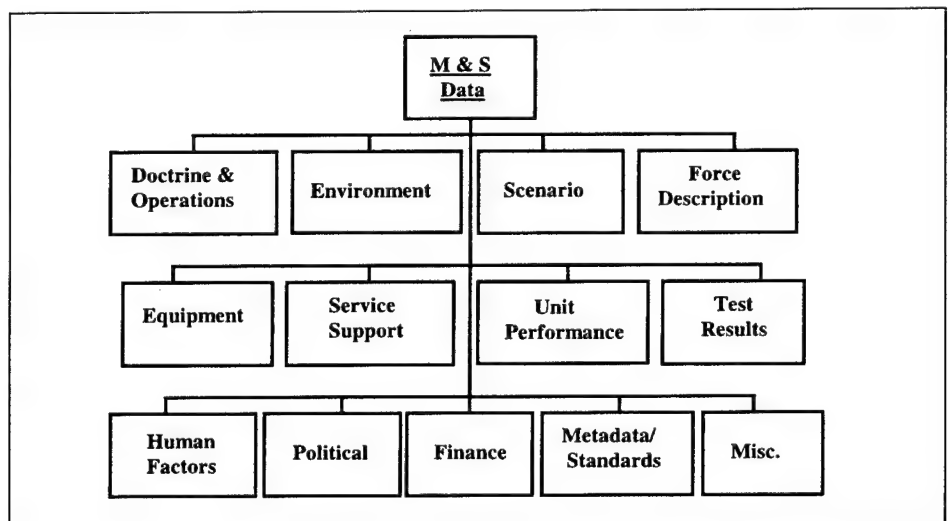


Figure 1. ADS Process



Figure 2. Top Level Taxonomy

collected in the ADS Library are available on-line as one of the major resources of the Modeling and Simulation Resource Repository (MSRR) at http://ads.msrr.dmso.mil.

A graphical depiction of the process is provided in Figure 1. Initial direction for the project was to attack the task from the top down, requesting the senior Model and Simulation representative of the Services, Agencies and Executive Agents (EAs) to provide a list of prospective sources to DMSO. DMSO requested that the lists be

prioritized to focus early metadata collection efforts on those sources that were most likely authoritative in nature. In FY97 a second direction was added. DMSO requested major M&S end-users within the community to identify the sources they were currently using and requirements they had that were not being adequately met, a bottom up approach. This bottom-up approach also provides the potential for early rewards from the project by identifying sources that would meet current shortfalls. Both top-down and bottom-up approaches have identified a large number of sources. More

recently, DMSO has been working directly with key M&S developers to identify data sources required to support their knowledge acquisition projects. These approaches are supplemented by independent research by the contractor team performing the task.

Sources identified are provided to Veridian's, Applied Technology Group (contracted by DMSO beginning in 1996 to support the Services, Components and EAs). Each source is contacted to initiate the metadata collection effort, if it is determined to be beneficial, on-site briefings are conducted to more clearly explain the project. The standard set of information (metadata) is collected on each source.

In addition to gathering the required set of metadata, responsibilities, definitions of data sources and data centers and development of guidelines for verification and validation (V&V) and how they pertain to M&S data are discussed with the sources. Veridian compiles the resulting information into a report, updates the ADS Library and provides the information to DMSO at six-month intervals.

The ADS Working Group developed a taxonomy of data source categories (13 top-level categories, see Figure 2, and 373 sub-categories not shown) to organize the identification of sources, production of metadata and to assist ADS Library search and discovery. Formal definitions have been developed and coordinated for each category. The ADS taxonomy "organizes" M&S information according to the natural divisions of labor among data producers.

At present, the ADS Library is:

- Centrally managed by DMSO;
- A single, homogenous data set stored in one location; and,
- Accessible via the Modeling and Simulation Resource Repository.

With the maturing of the Modeling and Simulation Resource Repository (MSRR) the ADS Library will become decentralized but transparently linked at various Component and Agency sites. Agreement on metadata constructs, content and common search processes are making this possible.

Designations are determined through the following process. DMSO reviews the information collected by Veridian for completeness. Sources are sorted by Component. The metadata sets are then provided to the appropriate Component. Each Component then designates each source according to Component-specific procedures. Designations and associated metadata are returned to DMSO for inclusion into the ADS Library. Sources that are not clearly identifiable as belonging to a specific Component, are non-DoD, or commercial sources are sent to all Components with interest in the respective data area. If different levels of authority are recommended by different Components, the ADSWG resolves the difference and assigns the authority to be placed on the source in the library, appropriate comments are included in the source description.

The product of the ADS Project can be effectively utilized to reduce the knowledge acquisition phase during both model development and employment. As an example: a Conceptual Model of the Mission Space (CMMS) developer interested in capturing the necessary aspects of the Army's involvement in logistics over the shore can use the ADS tool to locate and access the doctrinal sources both Joint and Service to understand the concepts. He would enter the ADS database and search for logistics, logistics over the shore, or more specific key words. The search would return all data sources that are specifically related to the key words, showing the level of authority associated with each. The list would contain documents, subject mater experts and instance data sources. The CMMS developer would likely be most interested in the doctrine. He would click on one of the sources listed, as an example, Joint Pub 4-01.6 Joint Tactics Techniques, and Procedures for Joint Logistics over the Shore (JLOTS), and would be provided the metadata on that specific source. If that metadata tells the developer that this source contains pertinent information to his task he can click on the hypertext link (Note: Not all sources listed in the ADS library have hypertext links that will take you to the end data. Release of the data is still controlled by the data producer or repository and many require an approval process) and be taken to the Joint Electronic Library where he can read the actual publication and acquire a printed copy if necessary. After reading the doctrine the developer could return to the source metadata and if necessary contact the publication POC for further detail. He would then go back to the search results looking for Army doctrinal documents or to identify Subject Matter Experts to provide sufficient detail to the CMMS abstraction.

**The ADS Library is available on-line today** and contains 1061 sources. The designation process for the last library update is still in progress. Today the library contains 287 Authoritative, 184 Approved, 9 Other, 17 SMEs, 16 Organizations, with 548 still in the designation progress. Additional sources are identified daily with the current list of sources to be investigated for possible inclusion standing at 793. Figure 3 is a detailed breakout of sources by service.

The current library supports a very robust key word or category search capability and a number of reports can be obtained from the database.

Use of models and simulations in the

| Service/Agency | Designated | SME/Orgs | In Process | Sources Identified |
|---|---|---|---|---|
| Army | 152 | 17/09 | 79 | 413 |
| Air Force | 23 | 00/01 | 55 | 196 |
| Navy | 3 | 00/02 | 68 | 36 |
| Marine | 0 | 00/00 | 17 | 10 |
| DIA | 4 | 00/00 | 1 | 6 |
| NIMA/Terrain EA | 26 | 00/00 | 27 | 0 |
| Air & Space EA | 0 | 00/00 | 24 | 0 |
| Ocean EA | 0 | 00/01 | 46 | 40 |
| OSD | 142 | 00/03 | 152 | 31 |
| JCS | 110 | 00/00 | 41 | 24 |
| Other Gov't | 6 | 00/00 | 31 | 36 |
| Commercial | 13 | 00/00 | 7 | 0 |
| Foreign | 1 | 00/00 | 0 | 1 |
| TOTAL | 480 | 17/16 | 548 | 793 |

**Figure 3. Detailed breakout of Sources by Agency**

## DATA SOURCES

*(continued from p. 15)*

operational, acquisition, testing, research and development, and training environments will continue to expand. Authoritative Data Sources are a key element in DMSO's efforts to improve credibility, composability, and reduce the cost of knowledge acquisition.

## References

[1]Department of Defense Modeling and Simulation (M&S) Master Plan (DoDD 5000.59-9P, October 1995).

## Biographies

Mr. **Jack Sheehan** *is the Director, Data Engineering Division, Defense Modeling and Simulation Office (DMSO) and the Technical Director for the Conceptual Models of the Mission Space (CMMS) Program. As DMSO Chief for Data Engineering, he is responsible for the Modeling and Simulations (M&S) Functional Data Administration Program, data standards development for the High Level Architecture, CMMS and representations of the environment, systems and human behavior, discovery and cataloging of DoD Authoritative Data Sources for M&S. He has over 12 years experience as a Senior Systems Engineer conducting basic research, architecture definition, engineering design, prototype implementation and at-sea feasibility demonstrations for US Navy combat systems.*

*Mr. Sheehan served four years in the Naval Nuclear Propulsions Directorate under the command of ADM* **H.G. Rickover.** *His active duty experience included design, implementation and at-sea demonstration of a triple redundant nuclear control system. He also developed an automated manufacturing line for nuclear fuel element production and designed and fielded an in-service high-temperatures annealing unit to repair damaged reactor vessels. Mr. Sheehan holds BS degrees in Electrical and Nuclear Engineering and an MS degree in Electrical and Computer Engineering.*

Mr. **David E. Kendrick** *is a senior staff member and Program Manager for Data related projects with Veridian, Veda Operations' Development Group. He holds a Bachelors degree in Civil Engineering and a Master of Science degree in Operations Research and Systems Analysis. He has been the Veda Project Manager for the Authoritative Data Sources Project since its initiation in 1996.*

*Mr. Kendrick has over 14 years of experience directly related with Modeling and Simulation in both the acquisition and training fields. He has worked for Veda for 3 years and previous to that he had 23 years of military experience as an Armor/Aviation/ORSA officer. He was the US Readiness Command's project manager for the development of the Joint Exercise Support System (JESS) for five years. JESS has become the Army's premier training simulation under the name of the Corps Battle Simulation (CBS). He was one of a six-man nucleus that formed the Joint Warfare Center at Hurlburt Field, FL in 1987. He served as the senior analyst for major armored systems acquisition programs for the Assistant Secretary of the Army for Research, Development and Acquisition for three years, providing analysis in support of programs such as the Abrams M1A2, M1 Upgrade and Armored Gun System. He developed the initial concepts for the Anti-Armor Advanced Technology Demonstration (A2ATD). He served as liaison officer between HQ TRADOC and HQ USAEUR focusing on doctrine development and use of simulation to train the force during the period of downsizing. During his tour as liaison he lead or participated in Partnership for Peace Project visits to Slovakia and Belarus. He has worked for Veda Inc for three years, initially as an exercise technical coordinator at the Joint Warfighting Center, providing guidance on major joint training exercises such as USCENTCOM's Internal Look, and currently as the Program Manager for data related projects under the Development Group of Veda.*

Ms. **Lana Eubanks McGlynn** *is the Special Assistant for Models & Simulations and Light Forces Studies to the Deputy Under Secretary of the Army for Operations Research (DUSA(OR)) in Washington, DC. She has over 27 years federal service in the fields of automation, logistics, operations research and M&S. Ms. McGlynn has a Bachelor of Science degree in Mathematics from Marshall University in Huntington, West Virginia and a Master of Science degree in Systems Management from University of Denver. She is a graduate of the Army Management Staff College, the US Army War College in Carlisle Barracks,* Pennsylvania *and the Executive Leadership Training Program at the Office of Personnel Management's Federal Executive Institute. She is a Certified Acquisition Professional, Level III, in the functional specialty of Program Management in the Army Acquisition Corps.*

*Since 1990 she represented the Army in all matters pertaining to data used in M&S. She served as the Army's Functional Data Administrator for M&S Data and held various leadership positions on the Defense Modeling and Simulation Office (DMSO) Working Groups (WGs) including co-chair of the Authoritative Data Sources WG. She regularly participates in Military Operations Research Society's (MORS) sponsored workshops and symposiums.*

Mr. **Mike Hopkins** *is the Deputy Director, Data Engineering Division, Defense Modeling and Simulation Office (DMSO) and co-chair of the ADS Working Group. He is also the DMSO program manager for the Order of Battle Data Interchange Format (OB DIF) and ADS project. He has over 10 years experience in wargaming theory, development and applications with more than 9 of those years in recent management positions determining program requirements and objectives and organizing and scheduling DBMS programs and projects in support of models and simulations.*

*His M&S responsibilities included Database Administrator (DBA) for USCENTCOM's Combat Analysis Group, project manager of USCENTCOM's Conventional Forces DataBase (CFDB) and development of Data Quality Engineering Tools (DQE). These tools were tested in Operation DESERT STORM and commended by General Swartzkopf as invaluable.*

*Mr. Hopkins retired from the US Army after 23 years of active duty. His active duty experience included over 10 years experience in Special Operations including two years in combat He developed command, control and communications (C3) requirements for a Unified Command Forward Headquarters in the Middle East, authored the first Theater Army war plans for Southwest Asia (SWA) and task-organized a newly formed Theater Army. His last military assignments were as Chief of Current Operations and Chief of the Plans Branch for USARCENT, J3 of Special Operations Command USCENTCOM and Chief of USCENTCOM Compartmented Plans Branch.* ❂

# 15th ISMOR: Another Success Story

E.P. Visco, FS

On 31 August 1998, the 15th International Symposium on Military Operational Research opened with the traditional welcoming activities in the Roberts Hall Mess at the Royal Military College of Science, Shrivenham, England. The Symposium was chaired with his usual skill by **David Faddy**, following in the footsteps of the late Professor **Ronnie Shephard**, founder of the ISMOR series. The Commandant of RMCS, Major General **Ash Irwin**, CBE, gave the welcoming address to the participants to initiate the formal sessions, running from 1 through 4 September, culminating in an open forum that last morning. The theme — *Is a revolution in analysis required?* — was identified in a surprisingly large number of the presentations. Normally, a theme is not as well covered in professional meetings such as this. No conclusion was reached as to the answer to the question posed by the theme; there were as many negative responses as positive and "maybe" responses.

Registration and administration of the Symposium was in the always capable hands of **Trish Follows**, who has the wonderful record of managing all 15 of the symposia; she was assisted by the equally efficient **Maggie Floyd**.

A total of 30 papers were presented. Another tradition of the ISMOR series is that no proceedings are published. The presenters bring sufficient copies of their papers so that all participants depart with a complete set, eliminating the need to print proceedings consisting of the collected papers. [Readers interested in a list of papers with authors' addresses may contact **E. P. Visco** at 3752 Capulet Terrace, Silver Spring, MD 20906; voice: 301.598.8048; facsimile: 301.438.0395; e-mail: visco03@ibm.net for a copy.] By national origin, papers were distributed as: 12 from the United Kingdom, 10 from the United States, three from Canada, two from NATO (one from the Consultation, Command and Control Agency and one from the Allied Rapid Response Corps) and one each from Germany, the Netherlands and Sweden. To whet your appetites, here are some of the titles, to give the flavor of the Symposium: "When Systems are Simulations: T&E, VV&A or Both?" (**P. A. Glasow** and **M. Boroswski**, USA; presented by Ms. Glasow); "Stochastic Analysis of US Army Deployments and Excursions" (LTC **P. J. DuBois**, USA); "Contrary Schools of Thought within Military Decision Making Groups" (**F. Cameron**, Canada); "Project Albert: A Well Tempered Revolution" (**A. G. Brandstein, G. E. Horne** and Capt **T. M. Strycharz**, USA; presented by Dr. Brandstein); "SALOMO, Decision Support to Airbase Logistics" (**N. vanElst**, Netherlands); "Representation of Fear and Shock in Combat Models" (**J. Moffat** and **L. Dodd**, UK; presented by Mr. Moffat); "Peacekeeping in Bosnia:

> The theme — *Is a revolution in analysis required?* — was identified in a surprisingly large number of the presentations. Normally, a theme is not as well covered in professional meetings such as this.

Fatality Estimates" (**C. A. Lawrence**, USA); and "Complexity Theory - The Simple Answer to All Our Problems" (**P. L. Grainger**, UK).

Participation in the Symposium was distributed as: United Kingdom: 58; United States: 25 (including 2 from USAEUCOM); Canada, Germany and Turkey: 4 each; NATO (2 from the ARRC and 1 from C-cubed), the Netherlands and Sweden: 3 each; France and Israel: 2 each; and Denmark and Singapore: 1 each. [The numbers may not be exact since they are taken from the list of participants prepared from advance registration and do not reflect last minute changes.]

MORS was well represented, although long-time ISMOR participants **Richard I. Wiles**, Executive Vice-President, and Professor **Peter Purdue** were not able to attend 15 ISMOR because of other demands. The MORSians at 15 ISMOR included Dr. **George Akst**, past USMC Sponsor's Representative; MAJ **B. J. Barris**; **W. J. Bauman**; **Mary F. Bonnet**; Dr. Alfred G. Brandstein, Director; Dr. **Paul Deitz**; LTC Patrick J. DuBois; LCDR **Aasgeir Gangsaas**; Priscilla A. Glasow, Director; Dr. **Robert L. Helmbold**; Dr. **Jacqueline Henningsen**, FS; **Frank Mahncke**; LTC **John B. Musser**; **Professor David A. Schrady**, FS and Past President; Eugene P. Visco, FS; and Dr. **Daniel Willard**, who represented **Walter W. Hollis**, FS, Army Sponsor of MORS and a long-time supporter of ISMOR.

The Professor Ronnie Shephard Memorial Lecture was delivered, as usual, at the banquet on 3 September. In a modest break with tradition, the talk was presented by a military man, LTG **E. F. G. Burton**, OBE, MA, Deputy Chief of the Defence Staff (Systems), UK. General Burton is well-known to ISMOR veterans (as a friend and associate of Professor Ronnie and dedicated supporter of the ISMOR series at RMCS, particularly notable during his tenure as Commandant) and to members of the US defense community (from his days as attaché in the British Embassy and in subsequent assignments on the Ministry of Defence staff). In a departure from the reminiscent nature of earlier talks, particularly by operations analysts of the World War II and Korean War periods, General Burton made a series of challenges to the military operations analysis community. General Burton placed emphasis on matters such as improved understanding of human behavior in and contributions to military operations and trade-off analyses to assist in the higher level decision making in the ministries and departments of defense.

Plans are underway for 16 ISMOR to be held at the RMCS about 6 September 1999. Suggestions for a theme or other suggestions are welcomed. Ideas can be sent to Mr. Visco, address above, or David Faddy, CDE Lanchester Building A3, DERA, Ively Road, Farnborough, Hantshire GU14 0LX, United Kingdom; voice: 011-44-1252-396200; facsimile: 011-44-1252-396207. ✪

# The United States Military Academy at West Point

by LTC **Steven Horton**
e-mail: AS9492@exmail.usma.army.mil

The 67th Military Operations Research Society Symposium (MORSS) will be held at the United States Military Academy 22-24 June 1999. Since it was founded on 16 March 1802, USMA and its graduates have played an important role in the history of the United States. Its mission is to educate, train and inspire the Corps of Cadets so that each graduate is a commissioned leader of character who is committed to Duty, Honor, Country; a career in the United States Army; and a lifetime of service to the nation. Graduates of the Academy include **Dwight D. Eisenhower, Douglas MacArthur, George S. Patton, H. Norman Schwarzkopf, John J. Pershing, Robert E. Lee, Ulysses S. Grant**, and astronauts **Frank Borman, Mike Collins** and **Edwin Aldrin**.

This summer, you have the opportunity to visit West Point and become a part of what has been accomplished here by attending the 67th MORSS. This article was written to motivate you to do so! First, to inspire you, we provide a few historical notes about mathematics and operations research at USMA. Next we offer some information about things to do when you come to West Point. Finally, we give some resources you can use to find additional information about West Point and the 67th MORSS.

## Mathematics and Operations Research at West Point

USMA graduates have made significant contributions in virtually every field of human endeavor, including the relatively new field of operations research and its parent discipline of mathematics. Mathematics has been an important part of the USMA curriculum from the earliest days of the institution. The act of Congress establishing USMA in 1802 provided for an engineer, in the rank of major, to be Superintendent, and two assistant engineers, in the rank of captain, to serve as educators of the Academy. Captain **Jared Mansfield** was one of the assistant engineers and was appointed Acting Professor of Mathematics in May 1802,
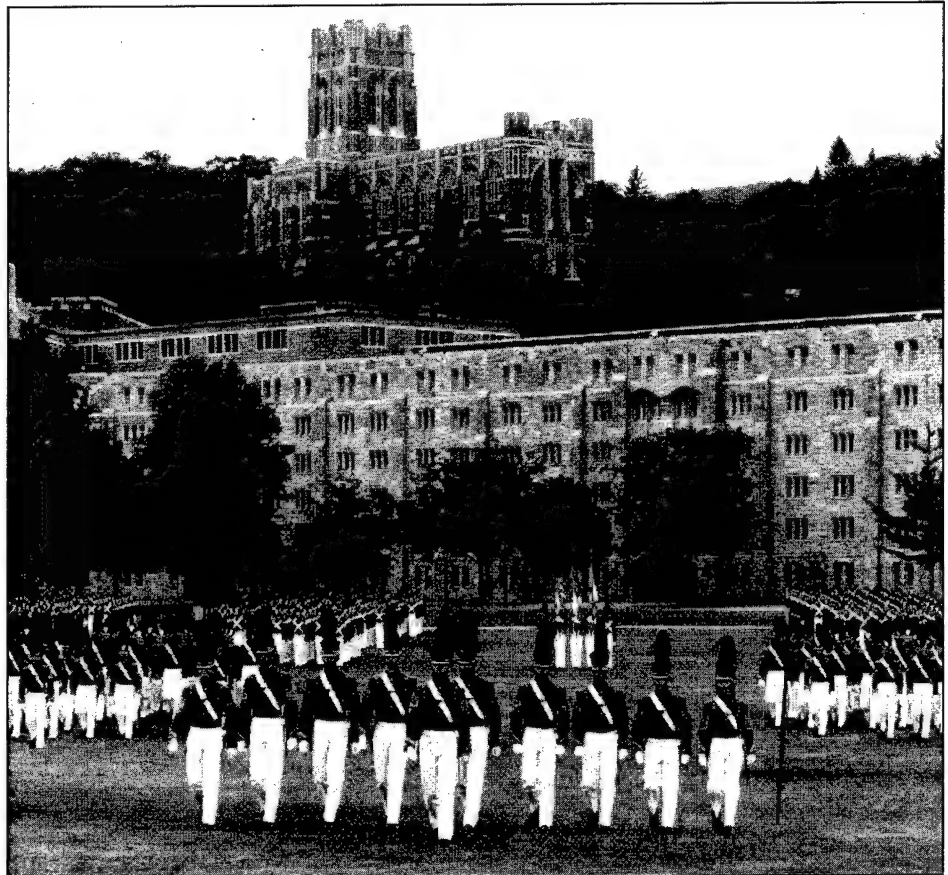
so the Academy's first educator was a math teacher. Both Robert E. Lee and **Omar Bradley** taught mathematics at West Point as well. Omar Bradley and Dwight D. Eisenhower served together in the 1930's under then Chief of Staff of the Army Douglas MacArthur solving problems of mobilization, mechanization and the relationship of military power to industrial capacity. Of course today we would call much of this work operations research, but that term had not yet been introduced. Since World War II, operations research has become an important part of the curriculum at USMA as it has at other institutions. Today the Department of Mathematical Sciences and the Department of Systems Engineering co-sponsor the operations research program. USMA, with leadership from these two departments, will carry on these educational traditions and simultaneously look forward

to the Academy's third century.

## Things to do in the West Point Area

West Point and the surrounding area offers visitors a great variety of things to do. Many of the most popular attractions at West Point are within easy walking distance of the Symposium site, Thayer Hall, Trophy point, the cadet barracks and the cadet chapel are all less than a mile away. These sites are visited by thousands of people from throughout the world every year. For those with an interest in physical fitness and projectile motion problems, the West Point golf course is close by and open to the public. In addition, tennis courts are available a short walk from Thayer Hall. The Cadet bookstore is in Thayer Hall and will be open every day during the Symposium. There are gift shops in both the West Point Visitors' Center and the

new Alumni Center.

The Hudson Valley has many other attractions. For those with an interest in history, the last encampment of **George Washington**'s Continental Army is near Newburgh, less than a half an hour from West Point by car. **Franklin D. Roosevelt**'s home and museum is about an hour away across the Hudson in Hyde Park, NY. Also near Hyde Park is the celebrated Culinary Institute of America which offers meals prepared by some of the finest *chefs de cuisine* in the world. If shopping is your desire, the Woodbury Commons outlet mall is about 20 minutes away in Harriman, NY. A more quaint shopping experience can be found in the old village of Cold Spring just across the river from West Point. Finally, New York City is only about an hour away by car or train.

"Information about MORS and the 67th MORSS is available at http://www.mors.org."

## For Further Information

More information on many of the topics discussed in this article is available on the World Wide Web. Information about MORS and the 67th MORSS is available at http://www.mors.org. General information about USMA's Department of Mathematical Sciences and Department of Systems Engineering can be found at http://www.dean.usma.edu/math/main.htm and http://www.se.usma.edu, respectively. Some interesting information about the history of the mathematics at West Point is posted at http://www.dean.usma.edu/math/history/usma/index.htm. If you have any questions regarding the site of the 67th MORSS, feel free to contact the site coordinators LTC Bob Acker, Department of Systems Engineering, email fr5178@ usma.edu or voice (914) 938-5536, or LTC Steve Horton, Department of Mathematical Sciences, email as9492@usma.edu or voice (914) 938-5905.✪

# Special Sessions at the 67th MORSS

Mr. **Brian Engler**, Systems Planning and Analysis
e-mail BENGLER@SPA.com

There are a large number of Special Sessions scheduled during the 67th MORSS. They begin at 1530 daily, and will be held in either auditoriums or larger rooms in order to accommodate everyone who will want to attend them. There are recurring Special Sessions with which many of you may be familiar. These include: the Rist and Barchi Prize awards and papers presentations, Junior/Senior Analyst Sessions, the Education Session and reports on several MORS Mini-Symposia and Workshops held over the past year. In addition, there are three Special Sessions, one each day, that will be unique to the 67th MORSS and in keeping with this year's theme of *Focusing Military Operations Research: From Our Heritage to the Future*.

On Tuesday, 22 June, the ongoing quest for coherent "Theories of Combat" that can provide descriptive foundations for combat analysis will be the focus of a Special Session. Papers and discussions will range from early attempts, such as those of the Soviets and The Military Conflict Institute, to conduct new research into complexity, and will give participants an appreciation for why it is so important, and so difficult,

to develop a self-consistent, empirically-based and comprehensive theory against which combat models can be compared. The awarding of the Rist and Barchi Prizes and presentation of the winning papers and the first of two Junior/Senior Analyst sessions are the two other Special Sessions that will be held simultaneously on Tuesday afternoon.

On Wednesday, 23 June, the "Military Operations Research Heritage" session will focus on examining some classic operational problems from each of the services — problems that have been addressed but not completely solved between the dawn of the modern period of operational analysis, around the time of World War II, and the present. These problems, one example is vulnerability and another is anti-submarine warfare, continue to challenge military OR analysts even today. The papers and ensuing discussion will afford participants the opportunity to convince themselves that even modern analytic techniques do not preclude the obligation we analysts have to step back from our problems on occasion and learn from our able predecessors. Simultaneously with this session on

| DAY | TIME | TOPICS |
|---|---|---|
| Tue | 1530-1715 | 1. Rist & Barchi Prize Awards/Prize Papers |
| | | 2. Junior/Senior Analyst #1 |
| | | 3. "Theories of Combat" |
| Wed | 1530-1700 | 1. Junior/Senior Analyst #2 |
| | | 2. C$^4$ISR in 2010 Workshop/Joint Experimentation Mini-Symposium & Workshop Reports |
| | | 3. "Military OR Heritage" |
| Thu | 1530-1700 | 1. Education Session |
| | | 2. SIMTECH 2007 Mini-Symposium/SIMVAL 99 Workshop Reports |
| | | 3. "The Innovation Process: Warfighting Advantage or Achilles' Heel?" |

# Junior/Senior Analyst Special Session for the 67th MORSS

Mr. **Jay Wilmeth**
SETA Corporation
e-mail: wilmetjl@js.pentagon.mil

The Junior/Senior Analyst program will take place for the tenth consecutive year at the 67th MORS Symposium at West Point. The program conducted during Special Session periods will take on a somewhat different format this year. Historically, this event of the annual Symposium has been very successful and has drawn both junior and mid-level audiences. Since the theme of the 67th focuses on the future and thus the junior analyst, it seems appropriate to key the activities of the Junior/Senior program toward that theme while, at the same time, accommodating the mid-level analysts who desire to interact with the seniors. With that in mind, the board of directors chose to expand the scope of the program this year. Accordingly, there will be two Junior/Senior Sessions.

The first session should attract those MORSians who understandably want to meet with and discuss important issues with the more senior analysts known to most of us. This session is scheduled for Tuesday afternoon from 1530-1700, in an auditorium that will accommodate a relatively large number of participants. The session will be open to all to hear distinguished senior analysts discuss topics relating to this year's theme. After introductory remarks from each of the seniors, the balance of the period will feature a moderator-led Q&A session from the floor.

Session two, scheduled for Wednesday afternoon from 1530-1700, in smaller classrooms, will be dedicated exclusively to the junior analyst. We define junior analyst as one who is relatively new to the Military Operations Research world and will benefit from the wisdom provided by those more seasoned analysts who have "been around." It will follow a format that has been successful in the past. There will be at least four meeting rooms separated along Service and OSD lines featuring mid-level seniors who are experienced

analysts and who are familiar with the day-to-day problems and issues facing the OR community. The sessions will feature two seniors, each of whom will address the concerns of the attendees. It is envisioned that the questions and discussions will center on career paths within the Military OR

> "A complete list of senior analysts participating in both sessions will be published in the June issue of the *PHALANX.*"

world and other "Hot" topics important to junior analysts. It is at this second session that junior analysts will have the opportunity to meet with those more experienced analysts who are currently making signifi-

cant contributions to military analysis and national security issues. We emphasize that, while all are welcome, the focus will be on the junior analyst during the Wednesday sessions. The sessions should feature no-holds-barred discussions and lively interchanges.

A complete list of senior analysts participating in both sessions will be published in the June issue of the *PHALANX.* Questions and suggestions about the program may be directed to the program co-chairs:

Mr. Jay Wilmeth
Land & Littoral Warfare
   Assessment Division
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US Army Model and Simulation Office
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Email: dunnwih@hqda.army.mil ✪

## SESSIONS

Wednesday afternoon, the second Junior/Senior Analysts session will be held and reports on the *C4ISR in 2010* Workshop and the *Joint Experimentation* Mini-Symposium and Workshop will be presented.

On Thursday, 24 June a panel of distinguished leaders will consider "The Innovation Process: Warfighting Advantage or Achilles' Heel?" This process develops new military technology, doctrine and tactics, and transitions them to the warfighter. In addition, the process must measure its progress against the anticipated threat and strive for an optimal allocation of scarce

resources. These leaders will offer the latest thinking on how the innovation process seeks to maintain American military dominance during this time of rapidly changing threats, technologies and warfighting concepts. The Education Session and reports on the *SIMTECH 2007* Mini-Symposium and *SIMVAL 99* Workshop will be conducted simultaneously on Thursday afternoon.

Your participation in as many of these Special sessions as you can attend is strongly encouraged — see the reference guide on page 20. ✪

# September 1998 Recipient of the MORS Stephan A. Tisdale Graduate Research Prize — Major Arent Arntzen

**THESIS:** Software Components for Air Defense Planning

**AUTHOR:** Arent Arntzen, Major, Norwegian Air Force B.S., Norwegian Air Force Academy, 1991; Master of Science in Operations Research-September 1998; Advisor Arnold Buss, Department of Operations Research

## ABSTRACT:

Modern offensive weapon technologies such as stealth and precision guided munitions have rendered Integrated Air Defense Systems increasingly vulnerable and ineffective. Stealth effectively reduces the performance of radar, but does not have the same impact on passive systems. Sensors have been the most important and vulnerable part of air defense systems throughout the history of air warfare. Research into passive sensors has been encouraging, but before passive sensor systems are produced, procured and deployed, analysis and planning must be conducted to quantify potential benefit and determine feasible system configurations.

As this type of analysis encompasses extremely complex system behavior, developing reusable and flexible simulation models becomes important. This thesis develops a prototype software component architecture and component library for building simulation models for air defense analysis. Sensor and airborne weapon simulation components are models for air defense analysis. Sensor and airborne weapon simulation components are demonstrated and used in an exploratory analysis of the impact of a network of Infrared Search and Track sensors. The analysis is based on a modern air defense system deployed in a realistic scenario. The component architecture and documentation methodology supports reuse, and provides model configuration flexibility with potential for growth in successive stages of analysis.

## Biography

Major **Arntzen** was born in Olso, Norway in 1960. He joined the Royal Norwegian Air Force in 1979 and completed his Pilot Training with the United States Air Force in Texas in 1981. Between 1981 and 1991, he flew the F-5 and F-16 aircraft and spent three years earning his Bachelor's degree at the Norwegian Air Force Academy. In 1991 he went back to the Air Force Academy to teach Air Power history and doctrine.

Upon graduation from the Naval Postgraduate School, Major Arntzen will be promoted to Lt Colonel to command the operations Group of Oerland Main Air Base. The unit comprises of an F-16 squadron and supporting units, and is Norway's Rapid Reaction Force (Air). ✪

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# AFIT 1998 MORS Prize Recipient

**THESIS:** A Value-Focused Thinking Approach to Offensive Information Operations

**AUTHOR:** Capt Michael P. Doyle

## ABSTRACT:

Measures of merit for offensive information operations (IO) are developed and applied to campaign-level and acquisitions support scenarios. Value-Focused Thinking and multiobjective value analysis are employed to develop these measures of merit based on the values and preferences of owning decision makers. Using these measures of merit, courses of action are developed as part of evaluating campaign-level planning. These courses of action are scored, evaluated, and ranked using these measures of merit. Similarly, the IO weapon systems used in the acquisition support scenario are scored, evaluated, and ranked based on these measures of merit. The sensitivity of the resultant alternative ranking is evaluated and its importance identified. This methodology is also used to characterize each alternative course of action and weapon system as to its ability to fulfill the owning decision maker's objectives. Finally, these characteristics are used to identify opportunities to develop new and better alternatives for each decision opportunity.

## Biography:

Captain **Michael P Doyle** was born on 17 May 1964 in Pennsylvania. In 1982, he graduated from both the Leechburg Area High School and the Lenape Area Vocational and Technical School where he was nationally ranked in chemical technology. After graduation, he attended and graduated from the Pennsylvania State University, with Bachelor of Science degree in Electrical Engineering. While attending Penn State he also managed a company and developed a

# SIMVAL 99 — Making VV&A Effective and Affordable

**Priscilla Glasow**, MITRE and Dr. **Dale Pace**, JHU/APL
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**Priscilla
Glasow**, MITRE

Dr. **Dale Pace**,
JHU/APL

The Simulation Validation (SIM-VAL) 99 Workshop was held at The Johns Hopkins University Applied Physics Laboratory on 26-29 January 1999. This special meeting explored ways to ensure Modeling and Simulation (M&S) credibility in effective, efficient, and affordable ways. The SIMVAL 99 Workshop was co-sponsored by the Military Operations Research Society (MORS) and the Society for Computer Simulation (SCS) International, and was the fourth in the series of SIMVAL workshops sponsored by MORS. SIMVAL 99 examined current technology supporting Verification, Validation and Accreditation (VV&A) and identified promising areas of possible technology development that could enhance VV&A. Such enhancements could make VV&A more effective for a given level of resources or could allow the same level of VV&A to be achieved with reduced resources. The SIMVAL 99 Workshop focused on three specific areas: (1) verification technology, (2) validation technology and methodology, and (3) the impact of technology on VV&A costs. The primary objectives of SIMVAL 99 were to provide a synopsis of the state of the art for VV&A technology and to suggest what should be done to most fully exploit that technology and advance VV&A.

The mini-symposium attracted 115 participants from government, academia, and industry. Three speakers provided a focus for the workshop discussions; the speakers and their topics are listed at the end of this article. Some of the presentations made at SIMVAL 99 are also available on the MORS web site at (http://www.mors.org).

## Structure and Focus

The workshop included three Working Groups and a Synthesis Group. The specific focus of each Working Group is further defined in the Terms of Reference. Each group was co-chaired and had an assigned reporter to capture the discussion points. The Working Group Co-Chairs and Reporters are also listed at the end of this article.

The Workshop was used to test two hypotheses. The first hypothesis was that the VV&A community is generally uninformed and untrained in the selection, development and application of tools and technologies that might assist in the conduct of VV&A activities. The second hypothesis was that the cost of performing VV&A might be considerably reduced if such tools and technologies were available and understood. The primary goal of the workshop then was to provide an educational forum in which participants could become familiar with existing tools and technologies. A unique feature of this special meeting was a display area in which invited vendors demonstrated current tools and technologies that have proven useful to various VV&A efforts. The workshop was also intended to provide a forum in which additional tools and technologies would be identified by the participants and examined for possible application to other VV&A endeavors.

## Workshop Challenges

The workshop participants were challenged in three ways. First, the need for education about tools and technologies was highlighted during the first two days of the workshop as participants worked to focus on tools and technologies. This challenge was especially strong as much of the VV&A community has been focused on definitions and processes during recent years, rather than tools and technologies. Second, the Working Groups struggled with reaching a common understanding from among the diverse groups represented by the two sponsoring organizations and the different perspectives of the analytical, acquisition, and training communities. Third, the workshop format was unfamiliar to some of the partici-

pants and the challenge to deliver a specified product at the end of the three day event required re-thinking of previously-held methods and rapid development of effective work groups.

Each Working Group was tasked with developing a synopsis of the key points of their discussions and the lessons learned. Significant issues, concerns and recommended solutions regarding the use of tools and technologies to support VV&A were also identified as a required product of each group. The following material summarizes the findings and conclusions of the workshop.

## Workshop Findings

The workshop findings were the result of the Working Groups' discussions, the identification of crosscutting issues by the Synthesis Group and the capstone observations of the Workshop Co-Chairs.

- The Modeling and Simulation (M&S) community, and the subset of people within it who are concerned with verification, validation, and accreditation, is so broad and diverse that effective communication is very difficult. Commonly accepted definitions for VV&A terms, such as those provided within the DoD M&S glossary and in formal DoD documents such as DoD directives and the *DoD VV&A Recommended Practices Guide (RPG)*, can be (and are!) interpreted in such different ways by various members of the M&S community that misunderstandings and communication confusion can abound. Lack of a clear articulation of the various perspectives that can be brought to M&S VV&A is part of the cause for this problem. Those working with software architectures have recognized the importance of multiple views for the architecture of a software development to provide a full description of the planned development, such as the *operational, system and technical views* espoused in the DoD Joint Technical Architecture. M&S VV&A has not matured to the place of having formalized the different perspectives that are equivalent to the different views in software architecture. Also contributing to

communication ambiguity in M&S VV&A is the lack of a mathematical level of specificity for most VV&A-related definitions. This problem manifested itself significantly in Working Group 1 (verification technology) and impeded their progress until the group decided to split and tackle verification issues independently from a global perspective and from a phase-specific verification process perspective. *It is believed that the breadth and depth of potential trouble that such communication difficulties can cause the M&S VV&A community are not fully appreciated by either VV&A practitioners or M&S management.*

- It appears that the VV&A community is not exploiting existing technology as much as desired. The reasons for this are manifold. First, M&S management and VV&A practitioners *as a whole* are woefully unaware of existing tools and technologies that could be used to support VV&A. Second, the VV&A community has focused primarily to date on defining terminology and developing methodologies and processes, and has not given adequate attention to the potential benefits of tools and technologies. Other reasons include the lack of a comprehensive survey of tools and technologies available to support the education of the VV&A community or the use of these resources in DoD and elsewhere. No central repository exists to document VV&A tool use or to serve as a resource for future applications of VV&A tools and technologies. Consequently, resources to support VV&A tool use are not identified routinely as part of M&S lifecycle planning. Even when tools are used, their use is often ad hoc and not repeated consistently from one M&S project to the next.

- It appears that advancement in computational capabilities and software engineering are proceeding more rapidly than comparable advances in M&S and VV&A. This problem is exacerbated by the limited awareness of M&S management and VV&A practitioners about the potential current and evolving technology to facilitate more effective and affordable VV&A. However, it appears that the time may be appropriate for major advances in application of M&S VV&A technology. Increased emphasis is being placed upon M&S use in system design and acquisition, as illustrated by the Simulation Based

Acquisition (SBA) program, and upon model-based decision aids for operational planning and execution. The Department of Energy (DOE) Accelerated Strategic Computing Initiative (ASCI) program includes a major software development component (with some emphasis on verification and validation of codes used in computational science and other areas of "grand challenge" problems) as well as the ASCI emphasis on advances in computational capabilities. Continuing computational advances and improvements in software development environments make automation of M&S V&V more viable just as they have already demonstrated such automation viability in software V&V. However, it should be noted that procurement officials, project managers, and planners also have to be aware of the benefits of leveraging tools used in M&S development for V&V efforts so that contracts, etc. will be written to effectively accommodate exchange and sharing of information, data, and tools necessary for these benefits to be realized.

- VV&A tools and technologies should be able to reduce program cost and risk if used properly. However, the importance of making the necessary investment to enable use of such M&S VV&A tools and technologies has not been widely recognized within DoD or elsewhere. In part, this situation exists because there is very little reliable cost benefit information available relative to M&S VV&A. Available cost information is not well organized for effective analysis (no standard cost element identification exists, useful and widely accepted metrics do not exist, etc.). This reduces the basis for cost benefit assessments to either mere postulation or to argument by analogy through comparisons between the dearth of tools used to support M&S VV&A with the more extensive application of automated tools in the software V&V arena.

- It appears that commercial forces will continue to drive the development of software V&V technology more rapidly than M&S management and VV&A personnel are likely to assimilate and exploit fully. However, that may not be the case for technology that is peculiar to M&S VV&A that is otherwise not generally applicable for software V&V. The stimulus of government Research and Development (R&D) funding may be required for needed progress in this area.

- A theme that was prominent in many parts of the workshop is the importance of talented people. Tools and technology can supplement, but will not replace the important role that knowledgeable people have in effective VV&A.

## Recommendations

- There needs to be a sustained educational campaign to ensure that M&S managers appreciate the importance of VV&A, understand the cost-benefit potential of VV&A for their applications and understand that the resources required to exploit VV&A technology in ways that are both effective and affordable. This educational campaign must also ensure that VV&A practitioners are aware of available methodologies, techniques, tools, technologies and the implications of their application or non-application. No single organization is likely to stimulate or provide the total impetus needed for such an educational campaign; instead *each of the MORS Sponsors, SCS leadership, DMSO and others are encouraged to establish educational campaigns within their spheres of influence or provide the necessary resources to allow their people to benefit from the educational campaigns of other organizations.* Such educational campaigns must be multi-faceted, not only addressing audiences of VV&A practitioners through short-courses, conference presentations and articles in peer-reviewed trade journals, but also addressing M&S managers.

- Several areas of research are required. At the most fundamental level, a relatively comprehensive survey of available VV&A tools and technologies is required. This survey should address how such tools and technologies should be used properly, identify appropriate applications and link tool use to phases of the M&S lifecycle. Information about resource requirements for tool use is also needed, such as data, personnel, training, equipment and financial considerations. Research should include establishment of a repository of VV&A tool information that identifies prior tool uses, results of tool application and costs of use. This repository may be either new or included within an existing repository. In addition, some level of support for basic research related to VV&A is indicated. This arena has been neglected

to date, and such investment is needed if the long-term promise of VV&A improvements from technology advancements are to be fully realized. The development of a formalized methodology is also needed to assist users in determining how good a simulation must be if it is to support a particular kind of application. When such guidance can be reduced to formalized methodology, it becomes amenable to automation, with the consequence of enhanced VV&A effectiveness concurrent with reduction in the cost of performing VV&A. In addition to DoD investments in research, agencies external to DoD that support basic M&S research, such as the National Science Foundation (NSF), other government agencies, commercial enterprises, or private foundations, should consider the urgent need for more rapid advancement of VV&A methodologies and technologies when dispersing their funds. A corollary to the above is the necessity for sharing information developed by such research throughout the M&S VV&A community

- Development of a widely accepted and widely used way to identify and describe different VV&A perspectives is also needed to reduce communication confusion among disparate elements of the M&S and VV&A communities. Concomitant with development of such standard perspectives (views) would be elaboration of VV&A-related terminology to provide greater precision of meaning. Specification of VV&A cost elements must be included in this work, so that meaningful VV&A cost data can be captured to provide a factual basis for development or refinement of VV&A cost models.

In addition to the above general recommendations, the M&S VV&A community should also give attention to the more specific recommendations contained within the synopses from the three working groups and the Synthesis Group.

## Tool Selection and Efficiencies of Use

The workshop participants found that tools and technologies selected for use in conjunction with VV&A will depend on many factors, including the intended tool use, the criticality of the application, the maturity of the product, corporate culture and the type of M&S development para-

digm. The cost of using tools and technologies similarly depend on these factors, as well as the stability and complexity of user requirements, security requirements, the time available in which to use technology, the probability of risk and its impact and the availability of reference data. The competence of VV&A agents was also noted as a factor that can influence the degree and quality to which tools and technologies are used.

## Existing Tools and Technology

Working Group 1 examined the use of tools and technologies to support verification. This group stated that comprehensive computer automated support tools would be useful to support requirements verification. They also found that conceptual models require tools that promote a standard approach for development. Working Group 1 determined that existing tools are sufficient for the design and coding phases of M&S development and verification.

Working Group 2 focused on validation technology and methodology. They claimed that it is easy to derive desired properties for validation tools, but difficult to find tools that demonstrate these properties. Working Group 2 noted that improvements are needed for tools that support the development of model validation criteria and validation of the conceptual model. They identified existing tools that can be used to support data validation, including database management systems, data quality engineering technology and data modeling tools. Although these tools are generally mature for software engineering purposes, they do not adequately support M&S validation activities. Similarly, the group identified statistical analysis, visualization, and after action tools that are useful for validation, but which require an improved focus to meet validation needs.

Working Group 3 identified existing tools and technologies and assessed their impact on VV&A costs. This group also identified some of the primary factors that affect VV&A costs and examined various technologies, including high order languages, integrated development environments and synthetic environments. They found that program management tools, automated repositories and database technologies offer the greatest potential for cost saving through the sharing and increased access to program information. Conversely, security technology was one example of technology that could reduce or increase VV&A

costs, depending on the degree to which the technology improved information sharing or limited access to data. The use of technologies to support VV&A was impacted most significantly by the amount of time available for its use. Working Group 3 also found that the availability of reference data was important to the use of tools and technology.

## Technology Recommendations

The Working Groups recommended leveraging instrumentation technology to generate real or experimental data against which simulations can be validated. They observed that tools are also needed to validate human behavior in interactive simulations and where human behavior is represented in M&S. Knowledge acquisition and engineering tools were identified as a far-term need, to support the translation of real world semantics to a conceptual model syntax. The Synthesis Group further stated the need for expressive high-level languages and a common conceptual model to facilitate effective communication between software engineers and subject matter experts.

## Methodology Recommendations

Although the workshop focused primarily on tools and technology, Working Group 2 was also tasked with examining the interplay of validation methodologies with technology. The group offered a variety of recommendations for the near-term, including the need for independent validation of conceptual models and the extension of validation methodologies to include simulation based acquisition and joint experimentation requirements. Their far-term recommendations included the need to better understand modeling theory and complexity to ensure that technologies employed are theoretically based and meet the needs of complex systems and environments.

The Synthesis Group also recommended that integrating methodologies are needed to allow the synthesis of VV&A activities into coherent metrics. Users can then apply such metrics to understand the decision risks associated with a given model and its intended use. The Synthesis Group also recognized the need for a common model for assessing the value of VV&A activities, especially hidden and deferred costs.

## Conclusions

Tools and technologies currently exist that could significantly enhance the conduct

of VV&A activities, but are not widely employed due to a lack of knowledge and understanding of their capabilities and applicability to VV&A. The MORS community must address these needs to attain the greater efficiencies and improved effectiveness that are offered by such tools and technologies. We must move beyond our current fascination with definitions and process diagrams, and focus on responsibly seeking new ways to reduce costs and risks to DoD programs. The legacy of MORS in the VV&A arena is strong and our community can again lead the practice forward.

## SIMVAL 99 Workshop Co-Chairs

Mrs. **Priscilla A. Glasow**, The MITRE Corporation

Dr. **Dale K. Pace**, Johns Hopkins University Applied Physics Laboratory

## Mini-Symposium Speakers

CAPT **Dennis K. McBride**, USN, Office of Naval Research — "The Future of Technology and VV&A in Warfighting Simulation"

COL **Kenneth Konwin**, USAF, Director, Defense Modeling and Simulation Office — "V&V Technology Review"

Dr. **Paul K. Davis**, RAND — "Beyond Box Checking: How Can Technology Help Model Building and VV&A?"

## Working Group Co-Chairs and Reporters

*Working Group 1, Verification Technology Co-Chairs:*
Dr. **Osman Balci**, Mr. **Robert Lewis**
Reporter: Ms. **Susan Solick**

*Working Group 2, Validation Technology and Methodology Co-Chairs:*
Mr. **Thomas Ruth**, Mr. **Gary Coe**
Reporter: Mr. **Dennis Laack**

*Working Group 3, VV&A Costs Co-Chairs:*
Mr. **Richard Kuhn**, Mr. **William Waite**
Reporter: Mr. **William Jordan**

*Synthesis Group*
Co-Chairs: Dr. **Jack Morrison**, Ms. **Simone Youngblood**
Reporter: Dr. **Walt Stanley**
For an extensive bibliography, please refer to the recommended readings listed in the Terms of Reference and to the read-ahead package located on the MORS web site at (http://www.mors.org). ☉

## OVERVIEW

designed, coded, tested and fielded. While the testing and fielding is being done, the specification of the next phase is underway. By managing the parallelism and feedback, several concurrent developmental iterations can help define and include the true requirements. By building smaller pieces and using the iterations to help, JSIMS is being built to satisfy the user's needs, even if they were unable to articulate them up front.

### Summary

JSIMS will support the entire training, rehearsal, doctrine development, and professional military education process by providing a set of integrated and flexible tools that can be composed based upon the needs of the exercise. In doing so, the JSIMS events can be distributed locally across machines and distantly across theatres while interoperating with live, virtual and constructive participants. JSIMS will replace numerous, redundant modeling and simulation systems that are not interoperable. JSIMS is being designed and built to mate with Go-to-War C4I systems and prepare commanders to coordinate their forces for whatever they might face in the future.

More information on the programmatics and the challenges facing JSIMS can be found on the JSIMS homepage at www.jsims.mil.

### Notes

a. Interestingly enough, the six independent contracting actions led to six different prime contractors. The Navy elected to develop the software in house.

### Biographies

*Dr. **David R. Pratt** is the first Technical Director of the Joint Simulation System (JSIMS) Joint Program Office in Orlando, Florida. He holds this position concurrently with an appointment as an Associate Professor in the Department of Computer Science, Naval Postgraduate School (NPS) in Monterey, California. Dr. Pratt holds a Ph.D. and M.S. in Computer Science from NPS and a B.S.E. in Electrical Engineering from Duke University. Dr. Pratt has left government service and is now a chief scientist/fellow at SAIC in Orlando.*

***Drew W. Beasley**, USN, is the Program Manager for the Joint Simulation System (JSIMS) Joint Project Office in Orlando, Florida. CAPT Beasley, has been the Commanding Officer of two ships of the line, the USS Pegasus (PHM 1) and the USS STUMP (DD 978). He has had numerous program management and policy level positions with in the Department of Defense. Captain Beasley's academic achievements include a BS in Oceanography from the United States Naval Academy, graduate of the National Defense University, Industrial College of the Armed Forces, and a Master of Public Administration degree from the George Washington University. He is an inducted member of Pi Alpha Alpha, the National Honor Society for Public Administrators.*

*Drew Beasley recently retired from Naval Service and has accepted a position at Systems Integration & Research, Inc., as Vice President of Operations.* ☉

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## AFIT

*database system for the Allegheny Ludlum Steel Corporation that is still used throughout the northeast. After graduation, he married his loving wife Barbara before entering active duty in the Air Force via Officer Training School. His first assignment was as a Minuteman ICBM Launch Control officer where he quickly rose to Flight Lead. During this tour he completed a Master of Science Degree in Space Studies at the University of North Dakota. His second assignment took him to the National Air Intelligence Center (NAIC) where he served as the Air Force and the Defense Intelligence Agency's national technical expert on aerospace electrical power conversion, generation, and storage. He completed his tour at NAIC as Deputy Chief of the Advanced Power and Weapons Technology Branch. Capt Doyle's third assignment was to the Air Force Institute of Technology, where he graduated in March, 1998 with a master's degree in Operations Research. Captain Doyle is currently assigned to the United States Strategic Command (USSTRATCOM), Offut AFB, NB; as an operations research analyst.* ☉

**CHANGE**

These criteria were applied to over 4000 courses, which resulted in initial identification of 1250 courses with technology reengineering potential.

These 1250 courses were then subjected to a more rigorous analysis. Consideration was given to several additional factors, including:

- Whether the course was a part of a pipeline;
- Whether there were substantial changes to the current course curriculum planned within the next year;
- If the course was part of a planned rating merger; and,
- What was the criticality of the rating being trained with respect to fleet requirements and manning level.

Commercial off-the-shelf and government developed media analysis software was applied to the courses. This software allowed us to determine the most optimum delivery methods for the course of instruction that factored in cost of delivery method and projected student success rates.

The next step was to determine, course by course, where the training benefits would occur and how to account for the benefits on a cost basis. For example, both private sector and our own analysis indicated that applying enhanced electronic instruction to selected curriculum would reduce time to train. This reduction is gained principally by increasing the amount of visual learning through improved graphics and animations that the new technology makes possible. A course that is currently 138 days in length with a annual throughput of 2500 students, obtaining a 15% course reduction (the low end of expected results) can reduce training man-year costs by 400 thousand dollars annually. A typical course delivered via Video TeleTraining (VTT) can reduce travel costs by 25-30 thousand dollars annually.

All the courses were then prioritized in terms of return on investment. These included:

- Calculating the expected reductions in total time to train;
- Attrition and setback rates;
- Temporary duty cost savings; and,
- Increases in throughput as a result of reduced total time to train.

The increased throughput without a corresponding increase in infrastructure is especially critical for high demand ratings. During Fiscal Year 1998 for example, CNET was able to train an additional 300 Fire Controlman because of the electronic trainer used in the Advanced Electronic Technical Core. Students using this method of training completed training, on average, in less than 100 days compared to the 137 days for traditional students.

The next step was to go beyond technology reengineering and identify advanced courses that had high compatibility with civilian training. This part of the study also focused on courses in highly technical areas where the Navy was facing challenges in delivering state-of-the-art training required to support state-of-the-art systems. One caveat, however, was not to include any direct combat systems training. In the first category of civilian equivalence, over 50 courses in the fields of welding, food preparation, small engine repair, barbering, machinery repair, supply and hazardous material were identified as having the potential to be trained in the private sector. After identification of the courses, research was performed to determine private sector providers who could likely provide the needed training at less cost than doing it in-house. These vendors were then categorized: community colleges, technical schools, industrial sites (both government and private) and traditional contract training. It was determined, for example, that locating an advanced culinary course in Norfolk (factoring in tuition and other costs) will result in a savings of 900 thousand dollars per year in manpower and travel costs.

With respect to improving capability to deliver state-of-the-art training, the field initially chosen for review, based on requirements and analysis of existing training, was information systems. This analysis has resulted in CNET contracting a demonstration project that makes available via the Internet over 400 information systems courses, covering topics from basic word processing to beginning router configurations. Initial response has been extremely favorable. If projections continue at the current pace, when fully implemented the Navy can expect to save over five million dollars a year in training and travel costs. The Navy is also piloting an advanced networking course using a private technical school. The management of networks both afloat and ashore is a critical requirement in ensuring information warfare dominance. In addition to reducing the cost of training, we believe this will also provide better and more timely training. This approach provides the trainer another tool in responding to the increased commercial off-the-shelf procurements and allows the delivery of training to fleet concentration areas.

As a direct result of these studies and analysis efforts, CNET has established a Local Training Authority (LTA) in every CONUS Fleet concentration area. The LTA is responsible for brokering training in their area. More directly, they locate the most effective, efficient, and economical training source/vendor for the customer. In addition, he must also work with the fleet customer to identify additional courses for reengineering.

The culmination of the first phase of analysis was the Program Objectives Memorandum 2000 (POM 00) training assessment. This assessment provided the detailed fiscal analysis to support the reengineering plan. It presented to Navy leadership in the form of the training baseline memorandum a five-year strategy to modernize the initial training system. This includes an affordable means of paying for the required investment and results in over 200 million dollars in savings to the Navy by year 2005. This plan was 70% funded by the Navy.

This assessment, presented to the Navy's operators, is designed to deliver Sailors to the fleet faster while maintaining or improving the quality of Navy training. It is designed to increase advanced training in the fleet concentration areas meaning Sailors will spend less time away from their homeports and families. It is also an opportunity for pull down enhancement/ sustainment training. Today, the Navy has over 70 courses available via video teletraining. There are currently 79 Learning Resource Centers (LRCs) supporting over 184 courses, 50 Automated Electronic Classrooms (AECs) supporting over 50 courses, over 400 courses available via the Internet and, most importantly, a funded plan that will reengineer individual training and keep the Navy producing the quality Sailors it needs into the 21st Century. Solid research based on analytical planning and a willingness to look outside the box, were the engines that drove the change. Those same engines will continue to guide the course.

## Biography

*Vice Admiral **Patricia Ann Tracey**, a native of The Bronx, New York, completed Women Officers School and was commis-*

sioned as an Ensign in 1970, following graduation from the College of New Rochelle with a Bachelor of Arts degree in Mathematics. She also holds a Masters degree, with distinction, in Operations Research from the Naval Postgraduate School.

Her initial assignment was to the Naval Space Surveillance Systems in Dahlgren, Virginia, where she qualified as a Command Center Officer and orbital analyst. Following a tour on the staff of the Commander in Chief of the Pacific Fleet, she served at the Bureau of Naval Personnel as the Placement Officer for graduate education and service college students.

From 1980 to 1982, Vice Admiral Tracey served as an extended planning analyst in the Systems Analysis division on the Chief of Naval Operations staff. She served as Executive Officer of the Naval Recruiting District in Buffalo, New York, until 1984, when she was assigned as a manpower and personnel analyst in the Program Appraisal division of the Chief of Naval Operations staff.

Vice Admiral Tracey commanded the Naval Technical Training Center at Treasure Island from 1986 to 1988. She then headed the Enlisted Plans and Community Management Branch on the Chief of Naval Personnel's staff for two years. She assumed command of Naval Station Long Beach, California, in 1990.

Upon completion of her command tour, Vice Admiral Tracey reported as a Fellow with the Chief of Naval Operations Strategic Studies Group at the Naval War College. Vice Admiral Tracey was assigned as the Director for Manpower and Personnel, J-1, on the Joint Staff from July 1993 to June 1995. From June 1995 to July 1996 she served as Commander, Naval Training Center, Great Lakes. She assumed the duties of Chief of Naval Education and Training and Director of Naval Training for the Chief of Naval Operations, 10 July 1996.

The Admiral's personal decorations include the Defense Distinguished Service Medal, three Legion of Merit awards and three Meritorious Service Medals.

Vice Admiral Tracey's husband, Richard Metzer, is a former naval flight officer from Pengilly, Minnesota. ○

## STABILITY

Another question that arises is: If solutions obtained by means of genetic algorithms are indeed more stable than those derived by conventional, optimal seeking methods, why is this so? It is my guess that the inherent stability of the solutions derived by algorithms that emulate evolution is due to the implicit role that stability plays in evolution. As populations (e.g., of plants and animals) evolve, they invariably tend toward stability as well as fitness. Mother Nature simply does not tolerate highly unstable populations of any species. By mimicking the evolutionary process, it would seem that genetic algorithms also provide solutions that are inherently stable.

## Acknowledgement

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## Biography

### Education

*Ph.D., Operations Research and Industrial Engineering, Virginia Polytechnic Institute and State University*

### Experience

*Professor, Department of Systems Engineering, University of Virginia*

*Chairman, Department of Systems Engineering, University of Virginia*

*Professor and Chairman, Department of Systems Engineering, University of Houston*

*Professor, Department of Industrial Engineering, Pennsylvania State University*

*Research Professor, University of Alabama, Huntsville*

### Authored

*Eight Books, including **Linear Programming in Single and Multiple Objectives** and **An Introduction to Expert Systems***

*250+ technical publications*

### Accomplishments

***1963** Development of Nonlinear Goal Programming*

***1968-1972** Development of the Multidimensional Dual, Integer Goal Programming, and Sequential Multiplex*

***1980-1990** Rulebase Design in Knowledge-Based Systems*

***Recent** Hybrid Systems in AI and OR, Ontogenic Neural Networks, Stability Analysis in Large-Scale Systems*

*First Engineering Design Application of Goal Programming*

*Recipient of the first Hartford Prize* ○

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## MAS PRESIDENT

work. This material needs to span the theoretical, practical, managerial and organizational. We have already begun this. Our 1MAS meeting produced proceedings that we are currently distributing to the attendees and will shortly be economically available for purchase by everyone. Dr. **J. P. Ballenger**, our Vice President, has begun to collect a volume of essays from our seniors on the future needs of our profession, tentatively entitled *War After Next*. Dr. **Jim Taylor**, NPS, has developed some intriguing panel discussions for the Cincinnati meeting, and we hope to have a MAS Plenary there. Also, we are planning some educational sessions at 2MAS.

In future columns: First MAS Survey and details of 2MAS. ○

## Means Objectives and Decisions

Means objectives describe how fundamental objectives are achieved. In the case of Joint Vision 2010 the overall means objective, "Full Spectrum Dominance" is described in the joint literature.[8] It has four operational concepts: dominant maneuver, precision engagement, full dimensional protection and focused logistics. Measuring outcomes with respect to each of these operational concepts could be thought of as evaluating means objectives. Figure 3 presents these objectives and some potential measures that are indicative of success along each of these concepts. There are three things that become apparent as one reviews the means measures that are presented. First, in this problem domain, the intersection with measures describing fundamental objectives is small. Second, success among these measures is highly interdependent. Dominant maneuver, as an example, requires accurate information about an enemy's location and sufficient logistical resources to support unit activities. Third, information related measures of effectiveness ($C^4ISR$ measures), the heart of JV 2010, are not evaluated directly. This is because information derives its value in the context of some set of deci-



| Maximize Warfighting Effectiveness | | | | |
| --- | --- | --- | --- | --- |
| Accomplish Mission | Minimize Casualties | Minimize Time | Prevent Repeat Aggression | Maximize Deployability |
| Allow penetration no deeper than xxxx KM<br><br>Restore U.N. sanctioned borders | U.S. military fatalities<br><br>U.S. injuries (50% disability) | Days of active combat<br><br>Days U.S. force deployed | Percentage of weapon systems destroyed<br><br>Percentage of infrastructure destroyed | Days to close a corps-sized joint task force into a theater.<br><br>Days to position a carrier task force in a region |

**Figure 2. Fundamental objectives with sample measures.**

sions or actions, and information is a commodity used by commanders to achieve fundamental objectives.

Computer-based simulations of combat and other battlefield activities are among the most common tools that are used to assess effectiveness along these means measures. We are keenly aware of the many specialized simulations that help decision makers "see the value" of choosing a particular investment strategy or

course of action. The strengths and weaknesses of the current generation of tools are discussed heavily in the literature.[9] In addition to the known weaknesses in the tools, there is strong evidence that the theoretical foundation supporting current combat models no longer adequately abstracts the key processes that occur on the battlefield.[10,11] This is particularly true of the decision making component of Command and Control (C2) and the required mathematical models supporting automated reasoning under uncertainty.

### Addressing Uncertainty

There are many sources of uncertainty that affect success in warfare. There is general agreement that these uncertainties affect the quality of analytic insights that are provided to decision makers. For example, there is clear evidence that small changes in combat simulation inputs can cause very significant, unexpected differences in outcomes.[12] The implications of uncertainty on the policy development process are also being discussed in the literature.[13] The analytic community sees the implications of uncertainty, and the computational technology is quickly emerging to efficiently address many of the uncertainties.[14]

A common misperception is that critical uncertainties can be addressed by developing higher resolution models of combat processes. Higher fidelity models provide the ability to increase the "realism" of a



# Full Spectrum Dominance:
# Means Objectives

| Dominant Maneuver | Precision Engagement | Full Dimensional Protection | Focused Logistics |
| --- | --- | --- | --- |
| Percent of combat engagements initiated on favorable terms<br><br>Percent of forces exposed to hostile fire | Percent of high-value targets destroyed<br><br>Percent of WMD sites destroyed<br><br>Number of collateral targets destroyed | Number of US fatalities<br><br>Percent of WMD sites destroyed<br><br>Number of US aircraft lost<br><br>Number of US ships sunk | Percent of time commander is logistically unconstrained<br><br>Number of engagement opportunities missed due to logistical shortfall |

**Figure 3. Measures for means objectives**

model. This realism can be beneficial for visually displaying results to decision makers. It is also useful for differentiating between alternative weapon systems within a small outcome space and resolving low-level system engineering type uncertainties. Additionally, increased fidelity also allows for realistic displays that are very valuable in training applications. Yet, this fidelity also requires "certain" data that are often not possible to produce because the required information is unknowable. Rather than looking to increase the fidelity of uncertain data, analysts and the policy makers they support would be better served by increasing the breadth of their perspective. This is accomplishable through the development of a systematic, consistent frame of reference for communicating clearly with decision makers concerning the sources and implications of the key uncertainties that affect outcomes along fundamental objectives.

A possible frame of reference for decomposing the sources of uncertainty consists of four components:

1) Uncertainty in the scenario;
2) Uncertainty in an opponent's behavior;
3) Uncertainty in technology performance; and,
4) Combinations of the above.

The first major source of uncertainty is with respect to scenario. The time, place and opponents in the next war are unknowable. Therefore, long-range planning in particular must address a broad set of climates, geographies, threat capabilities and US starting conditions. Moreover, there are significant uncertainties within existing planning scenarios. Factors such as an opponent's objectives, force strength and weapon system capabilities become increasingly uncertain the further into the future one projects.

The second source of uncertainty is with respect to an opponent's behavior. War is a multisided, adversarial activity. Opponents learn: from observation of past US military activity, from actual combat and from US doctrinal publications. As an opponent learns it will develop tactics and operational concepts that counter US technology and doctrine. The implication is that "scripting" an opponent's behavior to high levels of fidelity using postulated doctrinal templates could lead to misinformed decisions, particularly in campaign and mission-level models. A better strategy would be to evaluate force performance with respect to multiple, potentially new enemy doctrines.

Technical risk is also a significant source of uncertainty. The complex, technologically intensive nature of the Joint Vision 2010 force amplifies the significance of this risk. Two possibilities exist that call for additional comment. The first is that a technology or system may not perform as expected. As new technology and systems are introduced, analysis must explore the robustness of the entire warfighting system if the new technology fails. Ideally, the performance of a force should degrade gracefully as technology failures occur on the battlefield. Another possibility is that combinations of systems and technologies might interact in a manner that has unintended consequences.

Finally, a situation could arise entailing combinations of the three sources of uncertainty identified above. An effective countermeasure, introduced by an adversary against an emerging technology, is an example of a case of combinations of sources. Discussions of these combinations are inappropriate for the open literature.

## Conclusions

New technology, weapon systems and operational doctrine will continue to emerge as we move into the 21st century. It is already apparent that these advances are significantly changing America's "warfighting system." The next-generation system that is under development is complex and highly dependent on advanced technology. The new and emerging "measures of effectiveness" that are descried as means objectives are helpful in increasing our understanding of how the "warfighting system" works. However, it is incumbent on the military operations research community to ensure that analyses communicate clearly the benefits and risks of the evolving system in relation to the nation's fundamental defense objectives.

Properly structured analyses should be presented so leaders can clearly differentiate between means, means objectives and fundamental objectives in the context of the decision situation. Additionally, analysis must explore uncertainties with respect to means objectives, as these can identify systemic weaknesses and assist in their correction. This understanding is an important contribution to fielding the best force possible for the future. However, it is fundamental objectives that are reflective of the true reasons leaders and U.S. citizens are concerned about military effectiveness. These measures should be the foundation for defense analyses. They are truly the measures of effectiveness that will be used to judge the success or failure if, and when the evidence becomes unequivicable.

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### Biography

*Lieutenant Colonel **Dan Maxwell** is currently serving as a senior operations research analyst and the US Army representative at the Joint Warfighting System (JWARS) Office in the Office of the Secretary of Defense (OSD), Program Analysis and Evaluation Directorate. Prior to joining OSD, Dan was assigned to the U.S. Army Concepts Analysis Agency and provided analytic support for many DoD studies. He holds a Ph.D. in information technology from George Mason University, an MBA from Long Island University, and a B.S. in criminal justice from the Rochester Institute of Technology.* ◯

# New Tape on Operations Research Features Disney, Sunken Treasure Ship

The Institute for Operations Research and the Management Sciences (INFORMS ) has just released a new tape explaining its members' profession that includes examples from Disneyland, the sunken treasure ship The Central America and the Bosnian conflict.

The tape is expected to air on public television in 1999 and is currently available for purchase.

"Operations Research: The Science and Technology for Informed Decision Making" provides an introduction to the field through interviews with experts and engaging examples from real life.

A segment on queuing theory, for example, includes footage from Disneyland, which is a leader in applying operations research to easing waiting lines.

Search theory is illustrated by the techniques that METRON, Inc. used to help locate The Central America, a ship that sank with a load of gold during a storm before the Civil War.

A relatively uninvasive method used in early detection of breast cancer is featured in a segment out of the University of Wisconsin.

A US Air Force operations research study that Bosnia peace negotiators used to keep antagonists at the negotiating table is explored as well.

The tape is entitled "Operations Research: The Science and Technology for Informed Decision Making," and can be ordered from INFORMS by calling 1-800-446-3676, faxing 1-410-684-2963 or e-mailing informs@informs.org.
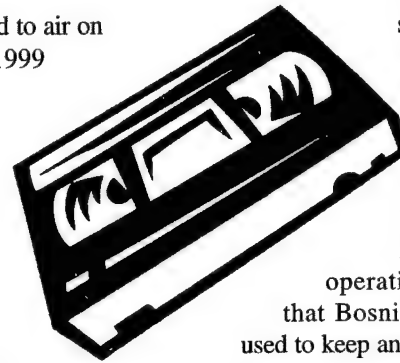
# A New Name — A New Home — A New Date

*by **E. B. Vandiver III**, FS*
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In the December 1998 issue of the *PHALANX* the Center for Army Analysis (CAA) formerly the US Army Concepts Analysis Agency announced its name change as of 1 October 1998; the Center's move to Fort Belvoir on 25 March 1999; and the dedication of its new home, Wilbur B. Payne Hall, named in honor of Dr. **Wilbur B. Payne**, first Deputy Under Secretary of the Army (Operations Research) and first Director of the TRADOC Systems Analysis Agency (TRASANA). Since the publication date of the bulletin the dedication ceremony has been changed. The ceremony will now take place on Friday, 28 May 1999 with the Payne family in attendance. Invitations will be mailed in the March-April timeframe.

# Operational Field Assessments

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Operational Field Assessments (OFAs) began in 1997, after Congress authorized the DoD's Director of Operational Test and Evaluation (DOT&E) to spend up to $3 million to demonstrate the program. Several OFAs have been completed with substantial results, but OFAs are not widely known in the test and evaluation community. Our purpose here is to explore how these assessments relate to operational test and evaluation.

An Operational Field Assessment is not a test, and OFAs will not replace operational test and evaluation. Rather, OFAs are coordinated efforts between a group of partners in DoD to support and assess operational requirements put forward by the CINCs. An OFA can be a field assessment or an experimental application of joint operational concepts to weigh their effectiveness against certain threats. An OFA may also demonstrate hardware or software applications or be used to prove operational or doctrinal concepts within a CINC's area of interest. Above all, OFAs are very limited in scope, their purpose usually being to provide quick support to the CINCs on near-term operational issues that otherwise might take years to achieve using joint exercises or joint testing.

## Background

During 1996, one of DOT&E's principal initiatives was to develop methods to help the operational test and evaluation (OT&E) community more directly support the theater or functional commanders-in-chief and their immediate subordinate commands. The OFA was one of the principal concepts chosen to accomplish this objective. The basic tenet of the OFA program is to support the CINCs in assessing how best to employ military assets in certain environments or against particular threats. OFAs also are designed to address adaptations of existing systems for a given mission to better understand the capabilities of those systems in new or unusual situations. They also address employment options that increase the capabilities of US military equipment. Generally, formal operational testing and evaluation of major weapon systems does not anticipate the needs addressed by OFAs because not every operational scenario can be tested, and new operational requirements continually arise as a result of the world's changing political and military factors.

## Defining OFAs

The OFA partnership operates on a memorandum of understanding between the DOT&E, the Director, Defense Intelligence Agency (DIA), the Director, National Security Agency (NSA) and the Director, National Reconnaissance Office (NRO). The Joint Chiefs of Staff (JCS) are OFA participants as well. At the program's outset, the JCS's Vice Chairman designated the J-8 as the JCS's point of contact for OFAs. The J-8 and the OFA partners then developed a coordination process to address the CINCs' requests for operational assessments. With the Unified Commands, several initial OFA requirements were identified, and the partners pursued the first of these assessments in early 1997.

The OFA concept not only has the potential to shorten the time needed to analyze the utility of a given technology or process, it also may provide data or help in forming concepts of employment that can measurably improve the preparation of formal operational test and evaluation, while reducing the cost of such testing. Since the concepts or systems being assessed during an OFA may well be used operationally in any number of critical situations, using proven operational evaluation methods as the background for assessing the potential utility of newly developing doctrines, practices or systems is ideal. Because there are many similarities between OFAs and operational testing, the DOT&E became the executive agent and DoD sponsor for the OFA partners.

Generally, a CINC has few alternatives to an OFA if he needs quick answers to joint operational problems. Neither large, joint command exercises nor joint test and evaluation can meet the CINCs' time-critical needs, since tests and exercises are too wide ranging and often need years of planning preparation. A joint test and evaluation, for example, normally runs for three years, and both tests and exercises are closely controlled toward specific goals. An exercise normally has complex training objectives, and will not provide the flexibility for experimentation or the employment of new technology or techniques. Tests are usually aimed at specific evaluations, and may not lend themselves to the add-on of assessing an OFA concept or technology.

OFAs, on the other hand, are small, flexible and fast — they are organized to meet a warfighter's needs now. Additionally, OFAs, if planned adequately, can demonstrate some aspects of a new technology's or concept's operational effectiveness. Thus, OFAs can provide advance data and understanding of candidate systems should they be developed further and brought to full operational test and evaluation, as some will. Already, several OFAs have been completed, producing a number of worthwhile observations.

## Practical Results

The first OFA, based on a request from the Commander-in-Chief, US European Command, focused on unusual, hybrid, surface-to-air threats that aircraft of the European Command and the US Central Command might face in their theaters of operation. This effort studied radars and weapons not normally used together as a system, but assembled via a supporting network to disguise their presence and present an unexpected threat to US or Allied aircraft. The basic idea for this potential

enemy tactic was not new, similar arrangements having been used by the North Vietnamese against American aircraft, and then by the Egyptians against the Israeli Air Force during the 1973 Middle East War. This assessment, however, centered on newer radar and weapon combinations that had not been seen in combat and whose dangers and operating characteristics were suspected but unverified. Since these were extraordinary weapon arrangements, the usual intelligence information was not complete enough to judge the threat they presented; past experience meant that a closer look in a field trial was warranted. Within seven weeks of the identification of support funding, a five-day experiment at Fort Bliss collected data on three unusual combinations of radars and weapons. Immediate results included both recommended improvements in aircrew operating procedures and a package of warning instrumentation for aircraft, as well as a refreshed understanding by the OFA partners of the warfighters' intelligence needs.

Another OFA, and one in which the authors participated, set out to demonstrate the usefulness of a computer-based service that would provide a distributed, collaborative planning (DCP) capability. This demonstration was actually of a prototype system being considered for a potential acquisition program. A unified command wanted this system to reduce plan preparation time and to increase the time available for course of action assessments and mission rehearsals. As with the hybrid surface-to-air threat, this assessment, too, was organized on short notice — less than three months. Again, as with the assessment of surface-to-air threats, this request came from a CINC. The assessment's setting, however, differed greatly in that it was part of a major joint force exercise in the southwestern United States rather than a separate, controlled activity.

Unfortunately, the exercise was not well suited to introducing the prototype system; the personnel using it lacked familiarity with it and tactics, techniques and procedures for its use had not been developed. Moreover, the candidate system itself lacked the maturity to withstand the stresses it faced in an operational versus a demonstration venue. The upshot was that the DCP attempt could not keep up with the operating tempo. The problem highlighted a clear consideration for future OFAs: the immediate difficulty with attaching a new methodology, system, or practice to an exercise is that if it fails to meet the players' expectations and needs, they will abandon it as they seek to fulfill their mission objectives in the old and well understood ways. That is what happened in this case. Although the system being assessed failed, the OFA succeeded. It gave the CINC information on which to base decisions about how to change and pursue future development and acquisition of a distributed, collaborative planning capability that his command needs.

Other OFAs already approved from the first year's authorizations are to be conducted in the near future. One, requested by the US Southern Command, is to provide an independent assessment of that command's exercise planning and execution processes, and to suggest areas where those processes may be improved through the use of techniques often employed by the operational test and evaluation community. This assessment will comprise three different activities in 1998: a peacekeeping exercise in Central America, a humanitarian and disaster relief exercise in the Caribbean, and an engineer exercise in Central America. Reviews will be prepared for the planning, execution, and post-execution phases of each with lessons learned, all aimed at improving the process for multi-participant, multi-national efforts.

An additional OFA will demonstrate the potential of a low-cost, airborne podded radar to conduct air-to-air intercepts. Another is studying the ability of the relocatable over-the-horizon radar to detect and track targets at extended ranges of 2,500 nautical miles. So far, this radar has demonstrated the ability to monitor the aerial activities of suspected drug smugglers in order to warn interdiction agencies of suspicious movements.

## Lessons Learned

Operational Field Assessments can range from a technical review to answer limited questions about certain hardware or system processes (rather narrow, in other words), to an assessment that seeks to survey wider avenues, including changes to hardware, software, or doctrinal and operational concepts. These broad assessments demand awareness of a number of problems that can arise unexpectedly when bringing a new concept through its initial scrutiny to operational trials. The effects of transitions from developmental or experimental use to operational employment should not be minimized or wished away just because the candidate seems right for the task. In fact, such transitions can be complex. Not anticipating them can cause the assessment to collapse — as happened with the DCP system — and an otherwise promising idea to fail. From what we have seen recently, the transitions an OFA candidate experiences as it is brought from an idea into the world of physical experiments parallels the types of transitional difficulties seen when moving a new system from developmental testing into OT&E.

OFAs, like operational tests, cannot be entered into haphazardly. They need a structure, and that structure roughly resembles that of a plan for an operational test. OFA preparation needs to set forth requirements, resources, evaluation criteria and a methodology. Moreover, the assessment must be internally disciplined and built according to an agreed-upon concept of operation. The internal discipline is needed so that the potential users do not deceive themselves, or are not deceived, into thinking that the system has utility based upon unsupported claims.

A critical issue to be settled at the outset of OFA preparation is for the potential user to articulate the results he expects to see demonstrated. If this can be done clearly, the requirements can be converted into testable or observable issues. Evaluators can then develop suitable pass/fail criteria to measure performance during the assessment.

Understanding the requirements and expected levels of performance will allow construction of the OFA's framework. With the distributed, collaborative planning system, for example, the authors reviewed the available material about the candidate system. Next, we drafted a set of operational effectiveness and operational suitability criteria, some of which we thought would be addressed during the immediately upcoming demonstration. We designed these criteria to be used as well for guiding assessments of the advanced system, should the command create a full-fledged development project. In this way, we hoped that the results could be matched against the command's overall require-

ments and evaluation issues so as to judge the true state of the candidate and discern its maturity. Information from the OFA also was intended to help create a baseline for future development and allow the command to adjust its expectations for the long-term project.

One of the more striking aspects of the distributed, collaborative planning OFA was the marked lack of coordination and organizational discipline leading up to the exercise. This was a stark contrast to the normal, step-by-step process that turns on a major operational test plan. Much of the OFA's disorganization stemmed from the command's hasty decision to try the system based, in good measure, on the contractor's assurances that it was fully developed and ready for operational use; in truth, it had a way to go in this regard. Additionally the exercise had been so quickly arranged that most of the players did not know how to use the new system.

Further adding to the problems was that, lacking an approved ORD, the requirements to be judged during the assessment were sometimes vague or uncertain; at other times, the requirements were based on the opinions of some of the players, yet not clearly defined in the minds of others. This pattern probably will not be unusual. Many OFA candidates are, by their very nature, ideas or semi-developed software or hardware for which no system ORD would be possible or appropriate. This can make understanding performance a challenge, and is all the more reason to work closely with the prospective user to develop a good plan that sets forth requirements, resources, evaluator criteria, and an appropriate assessment methodology. Just because OFAs are less formal than other test and evaluation settings, does not necessarily mean that all of them can be prepared on short notice. Some assessments simply require more planning time; the complexity of each needs to be carefully judged. Figure 1 illustrates a preparation sequence that would have been more reasonable for the DCP system, for example.

When we summed up the outcome of the DCP assessment and reviewed other such projects, it became apparent that a number of entrance criteria steps are needed if an OFA is to be successful:

- Preparing usable concepts of operation and employment, plus implementing procedures (even if these are no more than the partially developed ideas of a CINC or his staff). Lacking an ORD or CONOPS makes it all the more necessary to prepare some clear objectives for the candidates.

- Devising some method of certification to indicate that the candidate is ready for assessment, much like an operational test readiness review, although not nearly as detailed.

- Implementing training programs and packages to ensure that players know how to use the system.

- Preparing adequate databases that may be needed, such as map and terrain information, and the availability of data sources the users might need during the assessment.

- Applying effective system management procedures and capabilities.

- Providing adequate technical support for the systems and players.

- Providing for recovery and backup in the event of system crash.

- Employing an agreed-to doctrine that can be used to tie the many tasks into a cohesive whole, able to carry out the integrated mission.

A candidate system's proponents must not overlook the fact that when a new idea, process, or technique is adopted quickly, it often is not a part of the command's daily operation. The command's leaders often lack the time and understanding to incorporate it into their routine, and have not adapted their thinking to include it. As an addition to, rather than a part of, the unit's normal operation, a new system may well not receive the full consideration it needs to be successful in a complex exercise setting. To succeed in such an endeavor, sponsors and evaluators alike need to understand the importance of getting the system or process to be assessed into early use, so that people understand it and are willing to integrate it into their normal routine ( to trust it in the face of risk).

Military innovation via technological change holds both promise and serious potential problems. Evaluators, if they are to influence the promise or understand the risks and problems, need to become involved in the assessment as early in its planning as possible. Even so, early involvement by itself will not be enough. The assessment has to be made with full agreement among all participants of the goals and objectives, and the candidate's limitations must be well understood.

Getting back to the earlier distinction between narrowly defined OFAs intended to evaluate something like a potential threat, as opposed to broader OFAs that will lead to changes of operational doctrine, we must remember the most impor-

| D-9 months | D-8 months | D-7 months | D-6 months | D-5 months | D-4 months | D-3 months | D-2 months | D-1 months |
|---|---|---|---|---|---|---|---|---|
| Secure funding & contractor support | Planning conference with operators and contractors | Organize comm & training for participants; Define database needs | Start training; Receive Databases; SIPRNET analysis underway | Mini CPX for training | Mini CPX for training | Equipment on-site & running | Network stable | D-Day |

**Figure 1. For some OFAs, preparations can be deceptively complex. Attempting to expedite the distributed, collaborative planning system's operational field assessment, the sponsor provided only two month's preparation; the nine months shown in the timeline above would have been more realistic.**

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## ASSESSMENTS

tant issue: if the candidate in the OFA is to be used by troops who will depend upon it for mission success, even for their lives, it must prove itself to be clearly advantageous in a rigorous operational setting.

## Biographies

Mr. **John F. Kreis** received a bachelor of arts degree in economics from Willamette University in 1962 and master of arts degree in history from the University of Delaware in 1975. He served 22 years on active duty with the Air Force, specializing in air warfare analysis, and is the author of "Air Warfare and Air Base Air Defense," 1914-1973, and principal author of "Piercing the Fog Intelligence and Army Air Forces Plans and Operations in World War II."

John is currently a research staff member in the Operational Evaluation Division, Institute for Defense Analyses, Alexandria, VA.

Mr. **Edward F. Smith Jr.** received an electrical engineering degree from Northeastern University in 1970, with masters of science degrees in industrial engineering from New Mexico State University and in management from Salve Regina College. He has extensive experience in operations research with the U.S. Army TRADOC Analysis Activity, White Sands, NM, and with the Joint Connectivity Staff at Offutt AFB, NE. He served 21 years with the Army, during which time he was an associate professor of engineering management at West Point and as a professor of management at the Naval War College, Newport, RI.

Ed is currently a research staff member in the Operational Evaluation Division, Institute for Defense Analyses, Alexandria, VA.

Lt. Col. **Robert M. Newnam** serves in the US Air Force. Mike, as he is generally known, is assigned to the Office of the Director, Operational Test and Evaluation in the Pentagon. He was recently selected for promotion to Colonel. ◯

# THE LAST WORD

Julian Palmore

Since its inception the **John K. Walker** Award has heightened our need to have technical articles of the highest quality in *PHALANX*. This is tough to do. It's tough for authors because *PHALANX* only has space for around 3000 words per article which translates into around 3-4 pages. In a 36 page issue we can print only 4-5 technical articles. It's tough also because the articles must be timely, important and interesting to the *PHALANX* audience. *PHALANX* is a Bulletin. There are other things than technical articles that are timely, important and interesting. So we maintain a balance. *PHALANX* Online will help take the overload thanks to CAPT **Lee Dick**. I encourage all of you who want to write for *PHALANX* to do so. We need your support! ✪